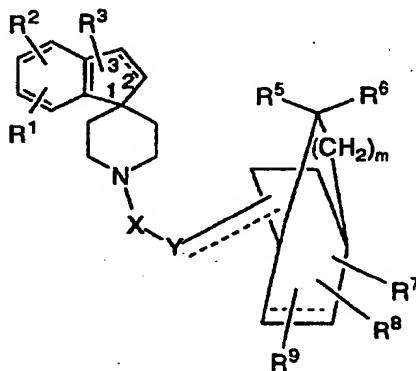




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(54) Title: PIPERIDINYLCAMPHORSULFONYL OXYTOCIN ANTAGONISTS**(I)****(57) Abstract**

Spirocyclic compounds of formula (I), where m is an integer from zero to one; Y is CH or CH_2 ; and X is $C=O$, CH_2 , PO_2H , PO_2Z , where Z is C_{1-10} alkyl, SO_2 , $CONH$, or SO_2NH . Such compounds are useful as oxytocin and vasopressin receptor antagonists useful in the treatment of preterm labor, dysmenorrhea and for the stoppage of labor preparatory to cesarean delivery, timing of parturition, uterine hyperactivity, endometriosis, hypertension, congestive heart failure, hyponatremia and cognitive disorders. Also disclosed are pharmaceutical compositions containing these compounds, methods of their use and methods of their preparation.

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TITLE OF THE INVENTION

PIPERIDINYLCAMPHORSULFONYL OXYTOCIN ANTAGONISTS

FIELD OF THE INVENTION

5 This application is a continuation-in-part of U.S. Serial No. 08/153,521, filed November 16, 1993, the contents of which are hereby incorporated by reference, which is a continuation-in-part of U.S. Serial No. 07/954,596, filed September 30, 1992, now abandoned, which is a
10 continuation of U.S. Serial No. 07/759,254, filed September 13, 1991, now abandoned, which is a continuation-in-part of U.S. Serial No. 07/612,344, filed November 13, 1990, now abandoned; the contents of all previous applications are hereby incorporated by reference.

 The present invention provides novel compounds, novel
15 compositions, methods of their use and methods of their manufacture, such compounds generally pharmacologically useful as agents in obstetric and gynecologic therapy. The aforementioned pharmacologic activities are useful in the treatment of mammals. More specifically, the compounds of the present invention can be used in the treatment of
20 preterm labor, stopping labor preparatory to Caesarean delivery, and in the treatment of dysmenorrhea. At the present time, there is a need in the area of obstetric and gynecologic therapy for such agents.

BACKGROUND OF THE INVENTION

25 In the field of obstetrics, one of the most important problems is the management of preterm labor. A significant number of the pregnancies progressing past 20 weeks of gestation experience premature labor and delivery, which is a leading cause of neonatal morbidity and mortality. Despite major advances in neonatal care, retention of the fetus *in utero* is preferred in most instances.

30 Tocolytic (uterine-relaxing) agents that are currently in use include β_2 -adrenergic agonists, magnesium sulfate and ethanol. Ritodrine, the leading β_2 -adrenergic agonist, causes a number of cardiovascular and metabolic side effects in the mother, including tachycardia, increased renin secretion, hyperglycemia (and reactive

- 2 -

hypoglycemia in the infant). Other β_2 -adrenergic agonists, including terbutaline and albuterol have side effects similar to those of ritodrine. Magnesium sulfate at plasma concentrations above the therapeutic range of 4 to 8 mg/dL can cause inhibition of cardiac conduction and neuromuscular transmission, respiratory depression and cardiac arrest, thus making this agent unsuitable when renal function is impaired. Ethanol is as effective as ritodrine in preventing premature labor, but it does not produce a corresponding reduction in the incidence of fetal respiratory distress that administration of ritodrine does.

It has been proposed that a selective oxytocin antagonist would be the ideal tocolytic agent. In the last few years, evidence has accumulated to strongly suggest that the hormone oxytocin may be a physiological initiator of labor in several mammalian species including humans. Oxytocin is believed to exert this effect in part by directly contracting the uterine myometrium and in part by enhancing the synthesis and release of contractile prostaglandins from the uterine endometrium/decidua. These prostaglandins may, in addition, be important in the cervical ripening process. By these mechanisms, the process of labor (term and preterm) is initiated by a heightened sensitivity of the uterus to oxytocin, resulting in part as a result of a well-documented increase in the number of oxytocin receptors in this tissue. This "up-regulation" of oxytocin receptors and enhanced uterine sensitivity appears to be due to trophic effects of rising plasma levels of estrogen towards term. By blocking oxytocin, one would block both the direct (contractile) and indirect (enhanced prostaglandin synthesis) effects of oxytocin on the uterus. A selective oxytocin blocker, or antagonist, would likely be more efficacious for treating preterm labor than current regimens. In addition, since oxytocin at term has major effects only on the uterus, such an oxytocin antagonizing compound would be expected to have few, if any, side effects.

The compounds of the present invention are also useful in the treatment of dysmenorrhea. This condition is characterized by cyclic pain associated with menses during ovulatory cycles. The pain is thought to result from uterine contractions and ischemia, probably

- 3 -

mediated by the effect of prostaglandins produced in the secretory endometrium. By blocking both the direct and indirect effects of oxytocin on the uterus, a selective oxytocin antagonist can be more efficacious for treating dysmenorrhea than current regimens.

5 An additional use for the present invention is for the stoppage of labor preparatory to Caesarean delivery. Certain spiroindanylpiperidines and spiroindenylpiperidines are known (U.S. Patents 3,654,287 and 3,666,764), however, they are reported to be useful as anesthetic agents which is quite distinct from the utility of the
10 present invention.

It is, therefore, a purpose of this invention to provide substances which more effectively antagonize the function of oxytocin in disease states in animals, preferably mammals, especially in humans. It is another purpose of this invention to prepare novel compounds which
15 more selectively inhibit oxytocin. It is still another purpose of this invention to provide a method of antagonizing the functions of oxytocin in disease states in mammals. It is also a purpose of this invention to develop a method of preventing or treating oxytocin-related disorders of preterm labor and dysmenorrhea by antagonizing oxytocin.

20 It has now been found that compounds of the present invention are antagonists of oxytocin and bind to the oxytocin receptor. When the oxytocin receptor is bound by the compounds of the present invention, oxytocin is antagonized by being blocked from its receptor and thus being unable to exert its biologic or pharmacologic effects.
25 These compounds are useful in the treatment and prevention of oxytocin-related disorders of animals, preferably mammals and especially humans. These disorders are primarily preterm labor and dysmenorrhea. The compounds would also find usefulness for stoppage of labor preparatory to Caesarean delivery. Additionally, such
30 compounds are useful in inducing contraception in mammals inasmuch as oxytocin antagonists have now been shown to inhibit the release of oxytocin-stimulated luteinizing hormone (LH) by anterior pituitary cells.

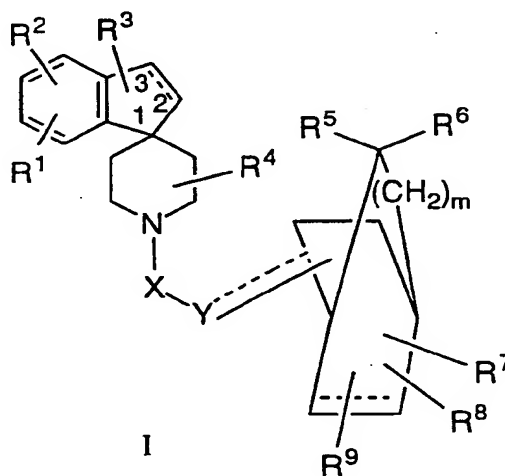
- 4 -

Compounds of the present invention are also inhibitors of vasopressin and can bind to the vasopressin receptor. These compounds are useful in inducing vasodilation, treating hypertension, inducing diuresis and inhibiting platelet agglutination.

Additionally, it has now been found that the compounds of the present invention are balanced oxytocin and vasopressin antagonists useful for treating preterm labor and dysmenorrhea.

SUMMARY OF THE INVENTION

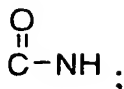
The compounds and their pharmaceutically acceptable salts and esters of the present invention are those of the general structural formula I



wherein
X is

$\begin{array}{c} \text{O} \\ \parallel \\ \text{C} \end{array}$,
 CH_2 ,
 PO_2H ,
 PO_2Z where Z is C_1 -10 alkyl,
 SO_2 ,
 SO_2NH or

- 5 -



5 Y is absent or is
CH or
CH₂;

m is an integer of from zero to one;
10 n is an integer of from zero to five;
p is an integer of from zero to five;
q is an integer of from zero to five;

R¹ and R² are each independently
15 hydrogen,
halogen,
hydroxy,
C₁₋₁₀ alkyl,
C₁₋₁₀ alkoxy or
20 trifluoromethyl;

R³ is
hydrogen,
halogen,
25 hydroxy or
oxo with the proviso that when R³ is oxo then the 2,3 bond
is saturated;

R⁴ is
30 hydrogen,
phenyl, or
C₁₋₁₀ alkyl,

R⁵ and R⁶ are independently
hydrogen,

- 6 -

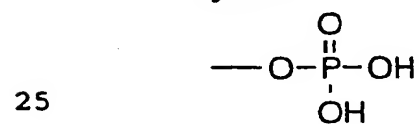
C₁₋₁₀ alkyl or
C₁₋₁₀ hydroxyalkyl; or

5 R⁵ and R⁶ together are
oxo or
unsubstituted or substituted C₃₋₆ cycloalkyl, where said
substituents are

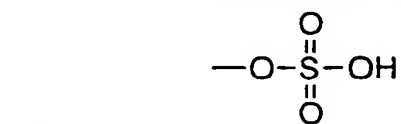
hydroxy,
10 C₁₋₁₀ alkyl,
C₁₋₁₀ hydroxyalkyl,
C₁₋₁₀ alkoxy or
C₁₋₃ alkoxyalkoxyalkoxyalkyl;

15 R⁷ and R⁸ are independently
hydrogen or
hydroxyl;

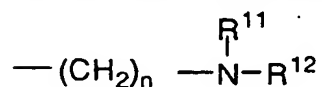
R⁹ is
20 C₇₋₁₀ alkoxy,
C₁₋₁₀ alkoxy carbonyl,
C₁₋₁₀ alkoxy carbonylalkylaminocarbonyl,
cyano,



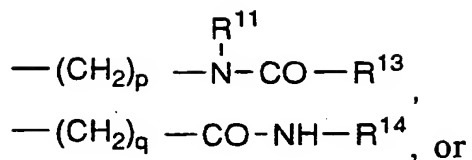
C₁₋₁₀ alkyl substituted phosphonate,



C₁₋₁₀ alkyl substituted sulfonate,



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5 unsubstituted or substituted C₁-10 alkyl where said
substituent is
R¹⁰; or

10 R⁷ and R⁸ are, together with the carbons to which they are attached,
joined to form a 5-membered heterocyclic ring containing 2 hetero atoms
where said hetero atoms are N and O;

R¹⁰ is

15 hydroxyl,
carboxyl,
C₁-10 alkoxy,
C₁-10 alkoxycarbonyl,
R¹⁵ or
cyano;

20

R¹¹ is

hydrogen,
C₁-10 alkyl,
C₁-10 carboxyalkyl or
25 C₁-10 alkoxycarbonylalkyl;

R¹² is

30 hydrogen,
C₁-10 alkylsulfonyl,
C₁-10 alkarylsulfonyl,
C₁-10 aralkylsulfonyl,
C₁-10 alkoxyarylsulfonyl,
aminosulfonyl,
C₁-10 alkylaminosulfonyl,
C₁-10 dialkylaminosulfonyl,

- 8 -

unsubstituted or substituted C4-15 cycloalkylalkyl, bicycloalkyl or tricycloalkyl where said substituent is

oxo or

sulfonyl substituted by unsubstituted or substituted C7-15 cycloalkyl, bicycloalkyl or tricycloalkyl where said substituents are

oxo,

oxime or

hydroxy;

R¹³ is

amino,

C1-10 alkylamino,

C1-10 alkyl which is unsubstituted or mono- or di-substituted by R¹⁶,

C2-10 alkenyl which is unsubstituted or substituted by R¹⁶, phenyl substituted by R¹⁷,

unsubstituted or substituted C3-8 cycloalkyl where said substituents are

C1-10 alkyl or

carboxy,

N disubstituted by C1-10 alkyl,

unsubstituted or substituted C7-15 bicycloalkyl or tricycloalkyl where said substituent is

carboxy,

C1-10 alkoxy or

R¹⁸;

R¹⁴ is

C1-10 alkyl,

C1-10 aminoalkyl,

C1-10 alkoxycarbonylalkyl, or

C1-10 carboxyalkyl,

- 9 -

R¹⁵ is

unsubstituted or substituted 5 membered heterocyclic rings
containing 1 hetero atom where said hetero atom is N and said
substituents are

- 5 oxo,
 amino,
 C₁-10 alkylamino,
 C₁-10 carboxyalkylcarbonylamino,
10 C₁-10 dicarboxyalkylamino or
 C₁-10 alkyloxycarbonylalkylamino;

R¹⁶ is

unsubstituted or substituted C₄-8 cycloalkyl where said
substituents are

- 15 hydroxy or
 carboxy,
 C₁₀-15 bi- or tricycloalkyl,
 halogen,
 hydroxy,
20 carboxy,
 oxo,
 oxime,
 C₁-10 alkylthio,
 C₁-10 alkylsulfinyl,
25 C₁-10 alkylsulfonyl,
 C₁-10 alkoxycarbonyl,
 R²⁰,
 R²¹,
 amino,
30 aminocarbonyl,
 C₁-10 dialkylaminocarbonyl,
 C₁-10 alkylamino,
 C₁-10 dialkylamino,
 C₁-10 alkylcarbamate,

- 10 -

5 C₁-10 alkylcarbonate,
C₁-10 alkylureide,
C₁-10 aralkylcarbamate,
unsubstituted or substituted aryloxy where said substituents
are
amino,
C₁-10 alkyl or
C₁-10 aminoalkyl,
10 C₁-10 aralkoxy,
unsubstituted or substituted C₁-10 alkaryloxy where said
substituent is
C₁-10 alkylcarbamate,
N disubstituted by C₁-10 alkyl and C₁-10 carboxyalkyl or
N tri-substituted by two C₁-10 alkyls and by C₁-10
15 alkoxycarbonylalkyl with the proviso that a trifluoroacetic
acid counterion be present;

R¹⁷ is
20 amino,
halogen,
C₁-10 alkyl,
C₁-10 alkoxy,
nitro,
phenylcarbonyl or
25 unsubstituted or substituted 5 membered heterocyclic rings
containing 1 hetero atom where said hetero atom is O and
wherein said substituent is
oxo;

30 R¹⁸ is unsubstituted or substituted heterocyclic rings selected from
azetidinyI,
pyrrolidinyl,
pyrrolyl,
piperidinyl,

- 11 -

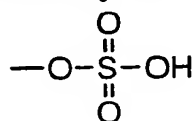
- 5 piperizinyl,
pyridinyl,
pyrimidinyl,
tetrahydrofuranyl,
furanyl,
dioxolanyl,
thienyl,
1, 3-thiazolidinyl or
10 tetrahydrooxazolyl; where said substituents are one or more of
oxo,
hydroxy,
carboxy,
amino,
15 C₁-10 carboxyalkyl,
C₁-10 alkyl,
C₁-10 alkoxy,
C₁-10 aralkoxy,
C₁-10 alkaryloxy,
20 C₁-10 alkoxycarbonyl,
C₁-10 alkoxycarbonylamino,
C₁-10 alkoxycarbonylalkyl,
C₁-10 aralkoxycarbonyl or
substituted or unsubstituted phenyl where said substituents
25 are
C₁-5 alkyl,
carboxy or
halogen;
- 30 R²⁰ is unsubstituted or substituted heterocyclic rings selected from
azetidinyI,
pyrrolidinyl,
pyrrolyl,
tetrahydroimidazolyl,
imidazolyl,

- 12 -

- 5 tetrazolyl,
piperidinyl,
pyridinyl,
hexahydroazepinyl,
thienyl,
1, 3-thiazolidinyl or
tetrahydrothiazinyl; where said substituents are one or
more of
- 10 C1-10 alkyl,
C1-10 aralkyl,
C1-10 aralkoxy,
C1-10 alkaryl,
amino,
15 C1-10 alkylamino,
C1-10 dialkylamino,
oxo,
oxime,
fused phenyl,
20 C1-10 alkoxycarbonyl,
C1-10 alkylcarbonate,
C1-10 alkylureide,
C1-10 alkylcarbamate, or
unsubstituted or substituted 5-membered heterocyclic
25 rings having 1 hetero atom where said hetero atom is
N and said substituent is one or more of
oxo or
fused phenyl;
- 30 R²¹ is
unsubstituted or substituted phenyl where said substituents are
halogen,
C1-10 alkyl,
C1-10 carboxyalkyl,
C1-10 alkoxy,

- 13 -

5- or 6-membered heterocyclic rings having 1 or 2 hetero atoms where said hetero atoms are N or S, hydroxy, carboxy or



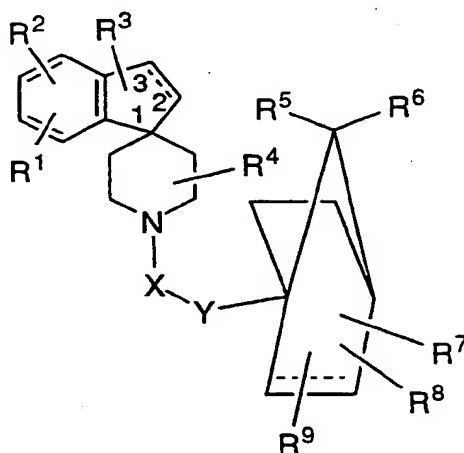
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In one embodiment of the instant invention are compounds of the formula



wherein

X is

25



CH₂,

PO₂H,

PO₂Z where Z is C₁-10 alkyl, or

SO₂;

30

R¹ and R² are each independently

hydrogen,

halogen or

C₁-10 alkyl;

- 14 -

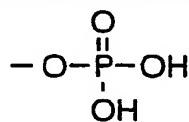
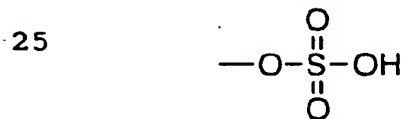
R⁴ ishydrogen or
phenyl;

5 R⁵ and R⁶ are independently
hydrogen or
C₁-10 alkyl; or

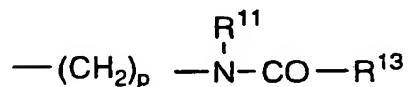
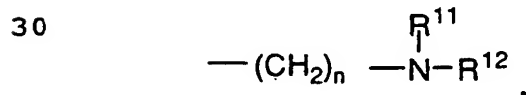
10 R⁵ and R⁶ together are
oxo or
unsubstituted or substituted C₃-6 cycloalkyl, where said
substituents are
hydroxy,
15 C₁-10 hydroxyalkyl or
C₁-3 alkoxyalkoxyalkoxyalkyl;

R⁹ is

20 C₇-10 alkoxy,
C₁-10 alkoxycarbonyl,
C₁-10 alkoxycarbonylalkylaminocarbonyl,

C₁-10 alkyl substituted

phosphonate,

C₁-10 alkyl substituted sulfonate,unsubstituted or substituted C₁-10 alkyl where said substituent is

- 15 -

R¹⁰; or

5 R⁷ and R⁸ are, together with the carbons to which they are attached,
joined to form a 5-membered heterocyclic ring containing 2 hetero
atoms where said hetero atoms are N and O;

R¹² is

10 hydrogen,
C₁₋₁₀ alkylsulfonyl,
C₁₋₁₀ alkarylsulfonyl,
C₁₋₁₀ alkoxyarylsulfonyl,
aminosulfonyl,
C₁₋₁₀ dialkylaminosulfonyl,
15 unsubstituted or substituted C₃₋₁₅ cycloalkylalkyl where said
substituent is
oxo or
sulfonyl substituted by unsubstituted or substituted C₃₋₁₅
cycloalkyl where said substituent is
20 oxo;

R¹⁴ is

25 C₁₋₁₀ alkyl,
C₁₋₁₀ aminoalkyl or
C₁₋₁₀ alkoxycarbonylalkyl;

R¹⁶ is

30 unsubstituted or substituted C₅₋₆ cycloalkyl where said substituent
is
hydroxy,
C₁₀₋₁₅ tricycloalkyl,
halogen,
hydroxy,
carboxy,
oxo,

- 16 -

5 C1-10 alkylthio,
C1-10 alkylsulfonyl,
C1-10 alkoxycarbonyl,
R20,
R21,
amino,
C1-10 alkylamino,
C1-10 dialkylamino,
C1-10 alkylcarbamate,
10 C1-10 aralkylcarbamate,
unsubstituted or substituted aryloxy where said substituents
are
amino,
C1-10 alkyl or
15 C1-10 aminoalkyl,
C1-10 aralkoxy,
unsubstituted or substituted C1-10 alkaryloxy where said
substituent is
C1-10 alkyl carbamate,
20 N disubstituted by C1-10 alkyl and C1-10 carboxyalkyl; or
N tri-substituted by two C1-10 alkyls and by C1-10
alkoxycarbonylalkyl with the proviso that a counterion be
present from the group consisting of C1-5 halogenated
25 carboxylic acids;

R¹⁸ is unsubstituted or substituted heterocyclic rings selected from
azetidinyI,
pyrrolidinyl,
pyrrolyl,
30 piperidinyl,
piperizinyl,
pyridinyl,
pyrimidinyl,
tetrahydrofuranyl,

- 17 -

furanyl,
dioxolanyl,
thienyl,
1, 3-thiazolidinyl or
5 tetrahydrooxazolyl, where said substituents are one or more of
 oxo,
 hydroxy,
 carboxy,
10 C1-10 carboxyalkyl,
 C1-10 alkyl,
 C1-10 alkoxy,
 C1-10 aralkoxy,
 C1-10 alkoxycarbonyl,
15 C1-10 alkoxycarbonylalkyl or
 C1-10 aralkoxycarbonyl;

R²⁰ is unsubstituted or substituted heterocyclic rings selected from
hexahydroazepinyl,
pyrrolidinyl,
20 pyrrolyl,
tetrahydroimidazolyl,
imidazolyl,
tetrazolyl,
piperidinyl,
25 pyridinyl,
azetidiny,
thienyl,
1, 3-thiazolidinyl or
tetrahydrothiazinyl; where said substituents are one or more of
30 C1-10 alkyl,
 C1-10 aralkyl,
 C1-10 aralkoxy,
 amino,
 oxo,

- 18 -

fused phenyl,
C₁-10 alkoxycarbonyl,
C₁-10 alkylcarbamate, or
unsubstituted or substituted 5-membered heterocyclic rings
having 1 hetero atom where said hetero atom is N and said
substituent is
oxo or
fused phenyl;

10 R²¹ is

unsubstituted or substituted phenyl where said substituents are

C₁-10 alkyl,
C₁-10 carboxyalkyl,
C₁-10 alkoxy,

15 5- or 6-membered heterocyclic rings having 1 or 2 hetero
atoms where said hetero atoms are N or S,
hydroxy,
carboxy or



In a class are the compounds selected from

25

30

- 19 -

5

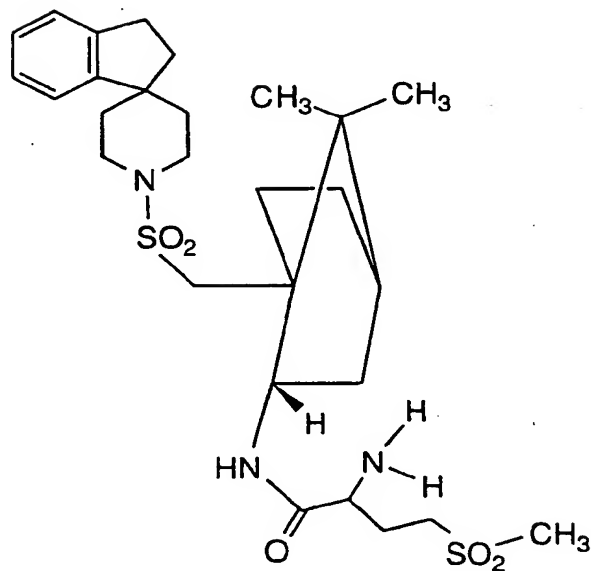
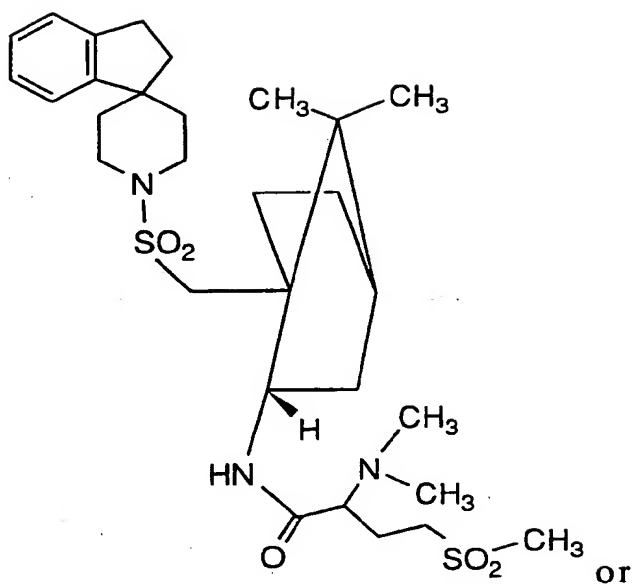
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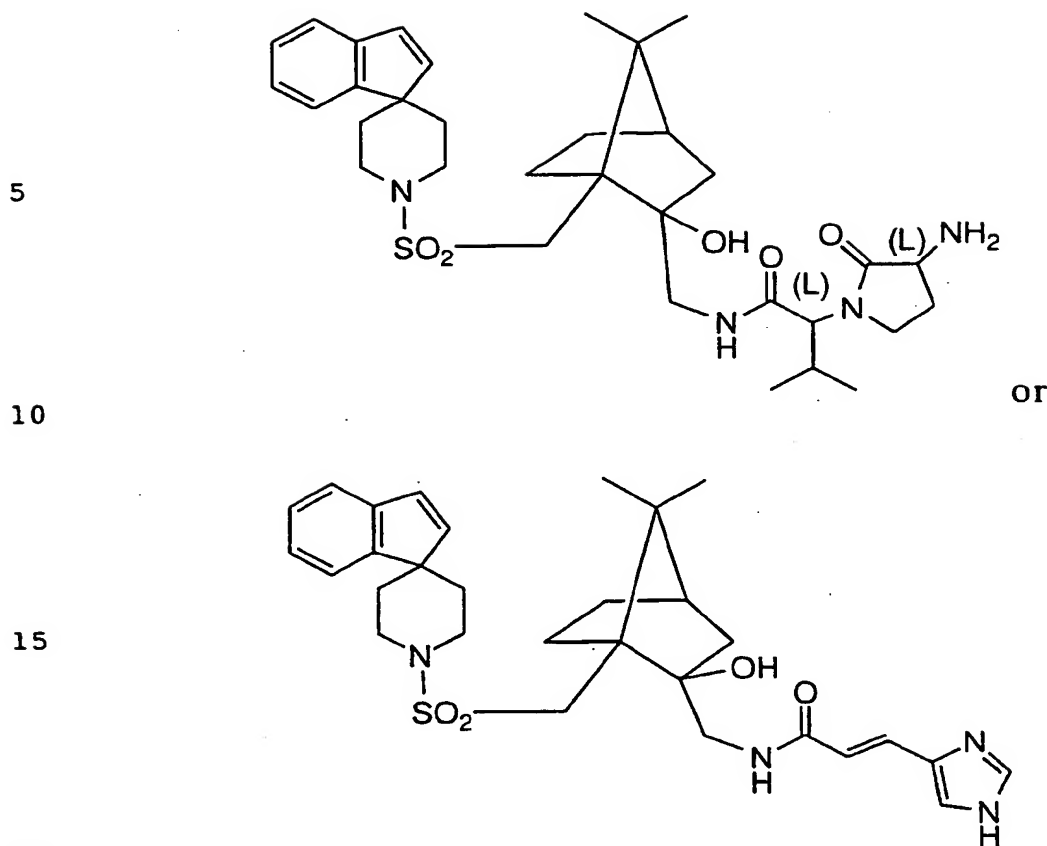
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30



In another class are the compounds selected from

- 20 -



Illustrative of the invention is a pharmaceutical composition, comprising a compound of formula I in a pharmacologically effective amount for antagonizing the binding of oxytocin to its receptor site, and a pharmaceutically acceptable carrier.

Illustrations of the present invention include methods of antagonizing the binding of oxytocin to its receptor site, preventing preterm labor, treating dysmenorrhea, and stopping labor preparatory to cesarean delivery, in a mammal in need thereof, comprising the step of administering to the mammal a pharmacologically effective amount of a compound of formula I.

Exemplifying the invention are methods of antagonizing vasopressin from binding to its receptor site, inducing vasodilation, treating hypertension, inducing diuresis, and inhibiting platelet agglutination, in a mammal in need thereof comprising the step of

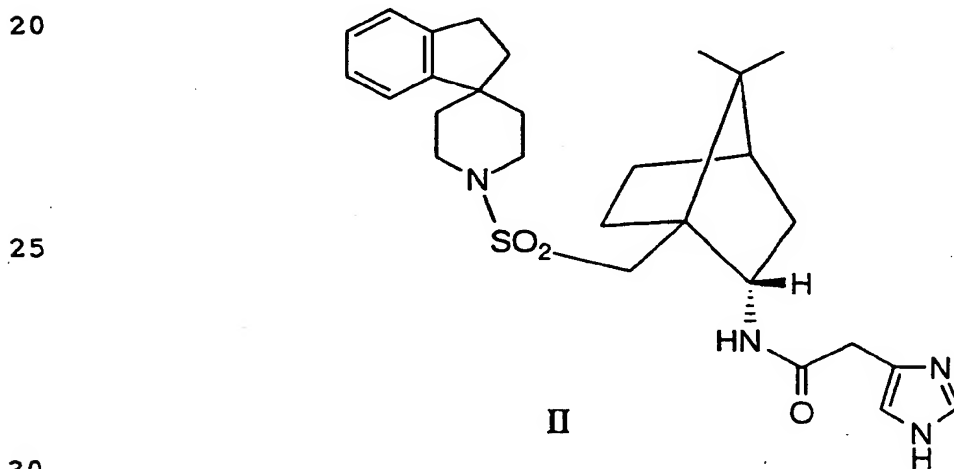
administering to the mammal a pharmacologically effective amount of a compound of formula I.

5 An example of the invention is a method of increasing fertility and embryonic survival in a farm animal comprising administering to the farm animal a pharmacologically effective amount of a compound of the present invention.

Further illustrating the invention is a method for improving survival of a farm animal neonate comprising controlling timing of parturition to effect delivery of the neonate during daylight hours by administering to a farm animal which is expected to deliver the neonate within 24 hours a pharmacologically effective amount of a compound of the present invention.

Another illustration of the invention is a method of controlling the timing of estrus in a farm animal, comprising administering to the farm animal a pharmacologically effective amount of a compound of the present invention.

Also included in the instant invention is a compound of the formula II



and the pharmaceutically acceptable salts thereof.

An embodiment of the invention is a pharmaceutical composition, comprising the compound of formula II in a

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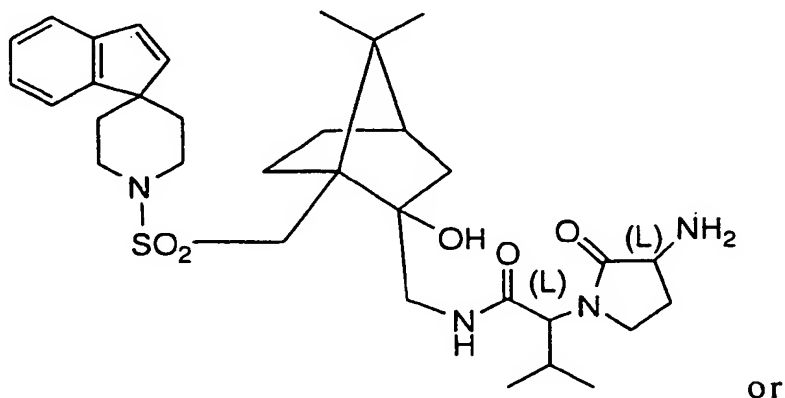
pharmacologically effective amount for antagonizing the binding of oxytocin to its receptor site, and a pharmaceutically acceptable carrier.

Illustrative of the invention are methods of antagonizing the binding of oxytocin to its receptor site, preventing preterm labor, treating dysmenorrhea, and stopping labor preparatory to cesarean delivery, in a mammal in need thereof, comprising the step of administering to the mammal a pharmacologically effective amount of a compound of formula II.

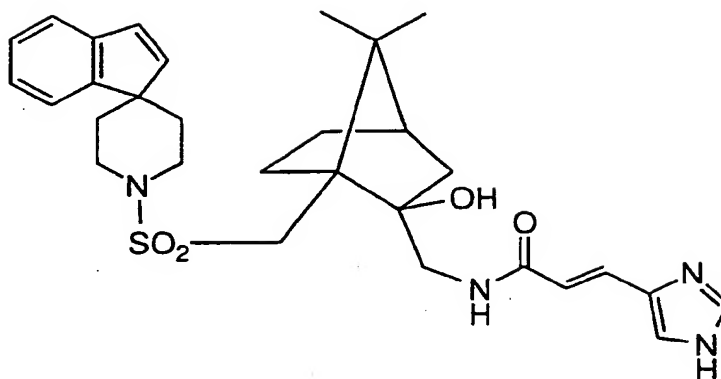
Also encompassed in the instant invention are methods of treating preterm labor and dysmenorrhea in a mammal in need thereof, comprising administering to the mammal a pharmacologically effective amount of a compound which binds to a human oxytocin receptor with a binding affinity which is no more than ten-fold higher or ten-fold lower than the binding affinity with which the compound binds to a human arginine-vasopressin-V_{1a} (AVP-V_{1a}) receptor.

More particularly illustrating the the invention are the methods of treating preterm labor and dysmenorrhea, wherein the compound binds to the human oxytocin receptor with a binding affinity which is no more than five-fold higher or five-fold lower than the binding affinity with which the compound binds to the human AVP-V_{1a} receptor.

Exemplifying the invention are the methods of treating preterm labor and dysmenorrhea, wherein the compound is selected from



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Salts and esters encompassed within the term "pharmaceutically acceptable salts and esters" refer to non-toxic salts of the compounds of this invention which are generally prepared by reacting the free base with a suitable organic or inorganic acid.

15 Representative salts and esters include the following:

Acetate, Benzenesulfonate, Benzoate, Bicarbonate, Bisulfate, Bitartrate, Borate, Bromide, Calcium Edetate, Camsylate, Carbonate, Chloride, Clavulanate, Citrate, Dihydrochloride, Edetate, Edisylate, Estolate, Esylate, Fumarate, Gluceptate, Gluconate, 20 Glutamate, Glycolylarsanilate, Hexylresorcinate, Hydrabamine, Hydrobromide, Hydrochloride, Hydroxynaphthoate, Iodide, Isothionate, Lactate, Lactobionate, Laurate, Malate, Maleate, Mandelate, Mesylate, Methylbromide, Methylnitrate, Methylsulfate, Mucate, Napsylate, Nitrate, N-methylglucamine ammonium salt, Oleate, Oxalate, Pamoate 25 (Embonate), Palmitate, Pantothenate, Phosphate/diphosphate, Polygalacturonate, Salicylate, Stearate, Sulfate, Subacetate, Succinate, Tannate, Tartrate, Teoclate, Tosylate, Triethiodide and Valerate.

The term "pharmacologically effective amount" shall mean that amount of a drug or pharmaceutical agent that will elicit the 30 biological or medical response of a tissue, system, animal or human that is being sought by a researcher or clinician.

The term "alkyl" shall mean straight or branched chain alkanes of one to ten total carbon atoms, or any number within this range.

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The term "lower alkyl" shall mean straight or branched chain alkanes of one to five total carbon atoms, or any number within this range.

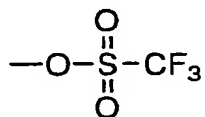
5 The term "alkenyl" shall mean straight or branched chain alkenes with one or more degrees of unsaturation at any position on the chain, of two to ten total carbon atoms, or any number within this range.

10 The term "alkynyl" shall mean straight or branched chain alkynes with one or more degrees of unsaturation at any position on the chain, of two to ten total carbon atoms, or any number within this range.

The term "aryl" shall mean phenyl, naphthyl or fluorenyl.

15 The term "cycloalkyl" shall mean cyclic rings of alkanes of three to eight total carbon atoms.

The term "trihaloalkylsulfonyloxo" shall mean the substituent



20 Whenever the term "alkyl" or "aryl" or either of their prefix roots appear in a name of a substituent (e.g. aralkoxyaryloxy), it shall be interpreted as including those limitations given above for "alkyl" or "aryl." Designated numbers of carbon atoms (e.g. C1-10) shall refer independently to the number of carbon atoms in an alkyl or
25 cyclic alkyl moiety or to the alkyl portion of a larger substituent in which alkyl appears as its prefix root.

The term "oxo" shall refer to the substituent =O.

30 The term "halogen" shall include iodine, bromine, chlorine and fluorine.

The term "preterm labor" shall mean expulsion from the uterus of a viable infant before the normal end of gestation, or more particularly, onset of labor with effacement and dilation of the cervix before the 37th week of gestation. It may or may not be associated with vaginal bleeding or rupture of the membranes.

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The term "dysmenorrhea" shall mean painful menstruation.

The term "Caesarean delivery" shall mean incision through the abdominal and uterine walls for delivery of a fetus.

5 As used herein, the definition of each expression when it occurs more than once in any structure, can be independent of its definition elsewhere in the same structure.

The term "substituted" shall be deemed to include multiple degrees of substitution by a named substituent.

10 Where multiple substituent moieties are disclosed or claimed, the substituted compound can be independently substituted by one or more of the disclosed or claimed substituent moieties, singly or plurally.

15 The compounds of the present invention, may have asymmetric centers and occur as racemates, racemic mixtures and as individual diastereomers, or enantiomers with all isomeric forms being included in the present invention. Therefore, where a compound is chiral, the separate enantiomers, substantially free of the other, are included within the scope of the invention; further included are all mixtures of the two enantiomers. Also included within the scope of the
20 invention are polymorphs and hydrates of the compounds of the instant invention.

Oxytocin (OT) and arginine vasopressin (AVP) are structurally related peptide hormones of the pituitary gland having distinct biological functions. OT is released from the pituitary in
25 response to stimuli related to parturition (e.g., labor, suckling of the neonate). Circulating OT then stimulates uterine activity to promote labor and delivery and contracts mammary gland myoepithelium to elicit milk-letdown postpartum. AVP, on the other hand, is secreted into the bloodstream by disturbances in hemostasis such as reduced
30 blood pressure or blood volume and/or increased plasma osmolality. AVP acts to correct these imbalances by enhancing peripheral vascular resistance and by promoting water reabsorption by the kidney. These effects of AVP are mediated by distinct receptors of the vascular smooth muscle (AVP-V_{1a} receptors) and kidney (AVP-V₂ receptors),

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respectively. AVP-V_{1a} receptors are also located in uterine smooth muscle to cause contraction and on platelets to mediate aggregation. By contrast, the contractile responses of the uterus and mammary glands to OT appear to be transduced by a separate, single receptor subtype. A
5 third, relatively obscure vasopressin receptor subtype, AVP-V_{1b}, has been identified in the pituitary gland where it mediates the stimulatory effects of AVP on adrenocorticotrophic hormone (ACTH) release. The human OT, AVP-V_{1a} and AVP-V₂ receptors have recently been cloned and expressed.

10 The ability of the compounds of the present invention to antagonize oxytocin makes these compounds useful as pharmacologic agents for mammals, especially for humans, for the treatment and prevention of disorders wherein oxytocin may be involved. Examples of such disorders include preterm labor and dysmenorrhea. These
15 compounds may also find usefulness for stoppage of labor preparatory to Cesarean delivery.

The oxytocin antagonist compounds of the present invention are also useful for improving reproductive efficiency in farm animals. In certain farm animals (e.g., sheep, cattle, swine and goats),
20 the beginning of the estrous cycle is typically marked by behavioral estrus when the female animal accepts the male for mating. Ovulation of the ovarian follicle occurs shortly after onset of estrus and cells in the follicle give rise to the corpus luteum. The cells that form the corpus luteum produce progesterone and they also produce oxytocin.
25 The secretion of oxytocin from the corpus luteum and/or pituitary acts on the uterine endometrium to stimulate the secretion of prostaglandins (in particular PGF) which, in turn, causes the regression of the corpus luteum of the ovary. PGF is, therefore, the luteolytic hormone. In the cycling animal (i.e., where mating and fertilization have not occurred),
30 destruction of the corpus luteum removes the source of progesterone which is key to the preparation of the uterus for pregnancy. The presence of a viable conceptus (i.e., the embryo and its associated membranes) is necessary to prevent the luteolytic process. In fact, the first key signal that the conceptus must produce is the one to prevent

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regression of the corpus luteum (i.e., the maternal recognition of pregnancy signal). Thus, in the animal where mating and fertilization have occurred, the conceptus secretes a factor that antagonizes the action of oxytocin to induce luteolysis. This results in maintenance of a functioning corpus luteum and the continued secretion of progesterone which is obligatory to the initiation of pregnancy.

Administration of an oxytocin antagonist of the present invention at this critical period after fertilization (i.e., just prior to or during the period of maternal recognition of pregnancy) supplements the natural signal from the conceptus (i.e., maternal recognition of pregnancy) to prolong corpus luteal function. The result is to increase pregnancy rates by enhancing the chances of impregnation through a reduction in embryonic loss. Thus, to improve fertility in a farm animal, a mated animal, for example, a mated ewe, is treated with an oxytocin antagonist compound beginning on between day 10 to day 15 after onset of estrus. The oxytocin antagonist compound is administered to the mated animal for a period of one day to three weeks, preferably one week to three weeks, most preferably one week to two weeks.

The compounds of the present invention are also useful in farm animals for controlling the timing of parturition so that delivery of neonates occurs during the daytime. Approximately 80% of livestock are delivered at night and up to 5 to 10% of newborns die because the deliveries are not monitored properly. An oxytocin antagonist compound of the present invention administered to the mother on the evening before expected delivery delays parturition so that the delivery occurs during the daylight hours. By delaying the timing of parturition, proper monitoring of the delivery and the neonates is ensured, resulting in increased survival rates of the newborns.

In addition, the oxytocin antagonists of the instant invention can also be used to control the timing of estrus in a cycling farm animal by preventing luteal regression. An oxytocin antagonist compound of the instant invention is administered to a cycling farm animal prior to expected estrus to prevent regression of the corpus luteum. Daily

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administration of the compound retards estrus until administration of the compound ceases. Preferably, the oxytocin antagonist compound is administered at least 1 day prior to expected estrus. By delaying estrus in a group of farm animals, a farmer can synchronize estrus among the group to provide time and cost savings in farm management.

The compounds of the present invention also bind to the vasopressin receptors and are therefore useful as vasopressin antagonists. Vasopressin antagonists are useful in the treatment or prevention of disease states involving vasopressin disorders, including their use as diuretics and their use in congestive heart failure.

It has now been found that compounds of the present invention are balanced oxytocin and vasopressin antagonists useful for treating preterm labor and dysmenorrhea. The terms "balanced oxytocin and vasopressin antagonist(s)," "balanced oxytocin/vasopressin compound(s)," and "balanced oxytocin/arginine-vasopressin (AVP)-V_{1a} compound(s)," as used herein, are defined as a compound which has a ten-fold or less separation between the binding affinity of the compound for a human oxytocin receptor and the binding affinity of the compound for a human AVP-V_{1a} receptor. Preferably, there is a five-fold or less separation between the binding affinities of the compound to the oxytocin and AVP-V_{1a} receptors. It is believed that a balanced oxytocin/vasopressin compound will provide a more effective treatment for preterm labor and dysmenorrhea. The fact that oxytocin receptors are up-regulated in the uterine myometrium during labor and before and during menstruation (AVP-V_{1a} receptors are also present but are not up-regulated), the observation that the uterus responds to both oxytocin and AVP and that the sensitivity of the uterus to the contractile effects of oxytocin is highest during labor and menstruation, and the fact that oxytocin/AVP-stimulated synthesis of contractile prostaglandins occurs during labor and menstruation indicates that a balanced oxytocin/vasopressin antagonist compound would provide effective treatment for both preterm labor and dysmenorrhea. In addition, it appears that the vasoconstrictor activity of AVP (AVP-V_{1a} response) contributes to uterine ischemia and pain. Thus, balanced

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oxytocin/vasopressin compounds, such as the balanced oxytocin/vasopressin compounds disclosed herein, provide a novel approach for the treatment of preterm labor and dysmenorrhea.

5 The compounds of the present invention can be administered in such oral dosage forms as tablets, capsules (each including timed release and sustained release formulations), pills, powders, granules, elixers, tinctures, suspensions, syrups and emulsions. Likewise, they may also be administered in intravenous (both bolus and infusion), intraperitoneal, subcutaneous or intramuscular form, all using
10 forms well known to those of ordinary skill in the pharmaceutical arts. An effective but non-toxic amount of the compound desired can be employed as a tocolytic agent.

15 The dosage regimen utilizing the compounds of the present invention is selected in accordance with a variety of factors including type, species, age, weight, sex and medical condition of the patient; the severity of the condition to be treated; the route of administration; the renal and hepatic function of the patient; and the particular compound or salt thereof employed. An ordinarily skilled physician or
20 veterinarian can readily determine and prescribe the effective amount of the drug required to prevent, counter or arrest the progress of the condition.

 Oral dosages of the present invention, when used for the indicated effects, will range between about 0.3-6.0 gm/day orally. Intravenously, the most preferred doses will range from 0.1 to about 10
25 mg/minute during a constant rate infusion. Advantageously, compounds of the present invention may be administered in a single daily dose, or the total daily dosage may be administered in divided doses of two, three or four times daily. Furthermore, preferred compounds for the present invention can be administered in intranasal form via topical use
30 of suitable intranasal vehicles, or via transdermal routes, using those forms of transdermal skin patches well known to those of ordinary skill in that art. To be administered in the form of a transdermal delivery system, the dosage administration will, of course, be continuous rather than intermittent throughout the dosage regimen.

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In the methods of the present invention, the compounds herein described in detail can form the active ingredient, and are typically administered in admixture with suitable pharmaceutical diluents, excipients or carriers (collectively referred to herein as
5 "carrier" materials) suitably selected with respect to the intended form of administration, that is, oral tablets, capsules, elixirs, syrups and the like, and consistent with conventional pharmaceutical practices.

For instance, for oral administration in the form of a tablet or capsule, the active drug component can be combined with an oral,
10 non-toxic pharmaceutically acceptable inert carrier such as ethanol, glycerol, water and the like. Moreover, when desired or necessary, suitable binders, lubricants, disintegrating agents and coloring agents can also be incorporated into the mixture. Suitable binders include
15 starch, gelatin, natural sugars such as glucose or beta-lactose, corn sweeteners, natural and synthetic gums such as acacia, tragacanth or sodium alginate, carboxymethylcellulose, polyethylene glycol, waxes and the like. Lubricants used in these dosage forms include sodium oleate, sodium stearate, magnesium stearate, sodium benzoate, sodium acetate, sodium chloride and the like. Disintegrators include, without
20 limitation, starch, methyl cellulose, agar, bentonite, xanthan gum and the like.

The compounds of the present invention can also be administered in the form of liposome delivery systems, such as small unilamellar vesicles, large unilamellar vesicles and multilamellar
25 vesicles. Liposomes can be formed from a variety of phospholipids, such as cholesterol, stearylamine or phosphatidylcholines.

Compounds of the present invention may also be delivered by the use of monoclonal antibodies as individual carriers to which the compound molecules are coupled. The compounds of the present
30 invention may also be coupled with soluble polymers as targetable drug carriers. Such polymers can include polyvinylpyrrolidone, pyran copolymer, polyhydroxypropylmethacrylamidephenol, polyhydroxyethylaspartamidephenol, or polyethyleneoxidepolylysine substituted with palmitoyl residues. Furthermore, the compounds of the

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present invention may be coupled to a class of biodegradable polymers useful in achieving controlled release of a drug, for example, polylactic acid, polepsilon caprolactone, polyhydroxy butyric acid, polyorthoesters, polyacetals, polydihydropyrans, polycyanoacrylates and cross-linked or amphipathic block copolymers of hydrogels.

The present invention is also directed to combinations of the compounds of formula I with one or more agents useful in the treatment of oxytocin related disorders such as preterm labor, dysmenorrhea and stopping labor prior to cesarean delivery. For example, the compounds of the instant invention may be effectively administered in combination with effective amounts of other agents used in the treatment of preterm labor, such as antenatal steroids (e.g., dexamethasone). Preferred combinations are simultaneous or alternating treatments of an oxytocin receptor antagonist of the present invention and an antenatal steroid. These combinations have beneficial effects on the neonate by both decreasing uterine activity to prolong gestation and increasing fetal maturation. In accordance with the method of the present invention, the individual components of the combination can be administered separately at different times during the course of therapy or concurrently in divided or single combination forms. The instant invention is therefore to be understood as embracing all such regimes of simultaneous or alternating treatment and the term "administering" is to be interpreted accordingly. It will be understood that the scope of combinations of the compounds of this invention with other agents useful for treating oxytocin related conditions includes in principle any combination with any pharmaceutical composition useful for treating preterm labor, dysmenorrhea or stopping labor prior to cesarean delivery.

The compounds of the instant invention can be prepared readily according to the following reaction schemes and Examples or modifications thereof using readily available starting materials, reagents and conventional synthesis procedures. In these reactions, it is also possible to make use of variants which are themselves known to those of

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ordinary skill in this art, but are not mentioned in greater detail. Reference can also be made to U.S. Patent No. 5,091,387, issued February 25, 1992, the entire disclosure of which is incorporated by reference. Additional reference can also be made to the method of
5 Matier, et al., J. Org. Chem., Vol. 36, No. 5, 650-654 (1971), the entire disclosure of which is incorporated by reference, on elaboration of indenenes and their 2-oxo derivatives to spiropiperidine analogs. Also incorporated by reference is a variant of this procedure described in
10 Matier, et al., J. Org. Chem., Vol. 36, No. 5, 650-654 (1971).

The most preferred compounds of the invention are any or all of those specifically set forth in these Examples. These compounds are not, however, to be construed as forming the only genus that is considered as the invention, and any combination of the compounds or their moieties may itself form a genus. The following examples further
15 illustrate details for the preparation of the compounds of the present invention. Those skilled in the art will readily understand that known variations of the conditions and processes of the following preparative procedures can be used to prepare these compounds. All temperatures
20 are degrees Celsius unless noted otherwise.

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Abbreviations used in the Examples are as follows:

BOP = benzotriazol-1-yloxytris(dimethylamino)phosphonium
hexafluorophosphate

5 DCM = dichloromethane

DIEA = diisopropylethylamine

DMF = dimethylformamide

EtOAc = ethyl acetate

EtOH = ethanol

10 EDC = 1-ethyl-3-(3-dimethylaminopropyl)carbodiimide

FAB MS = fast atom bombardment mass spectroscopy

HOBT = 1-hydroxybenzotriazole

HPLC = high pressure liquid chromatography

MeOH = methanol

15 NMR = nuclear magnetic resonance

THF = tetrahydrofuran

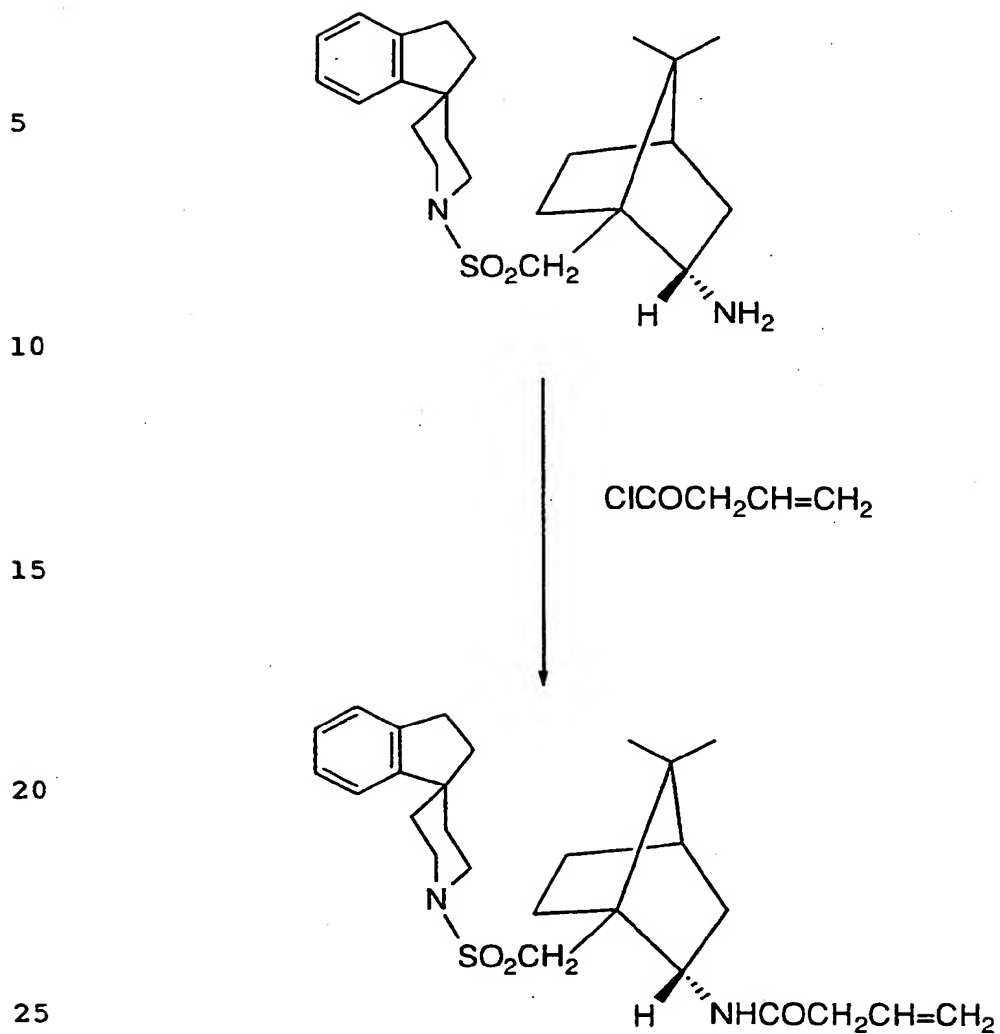
TLC = thin layer chromatography

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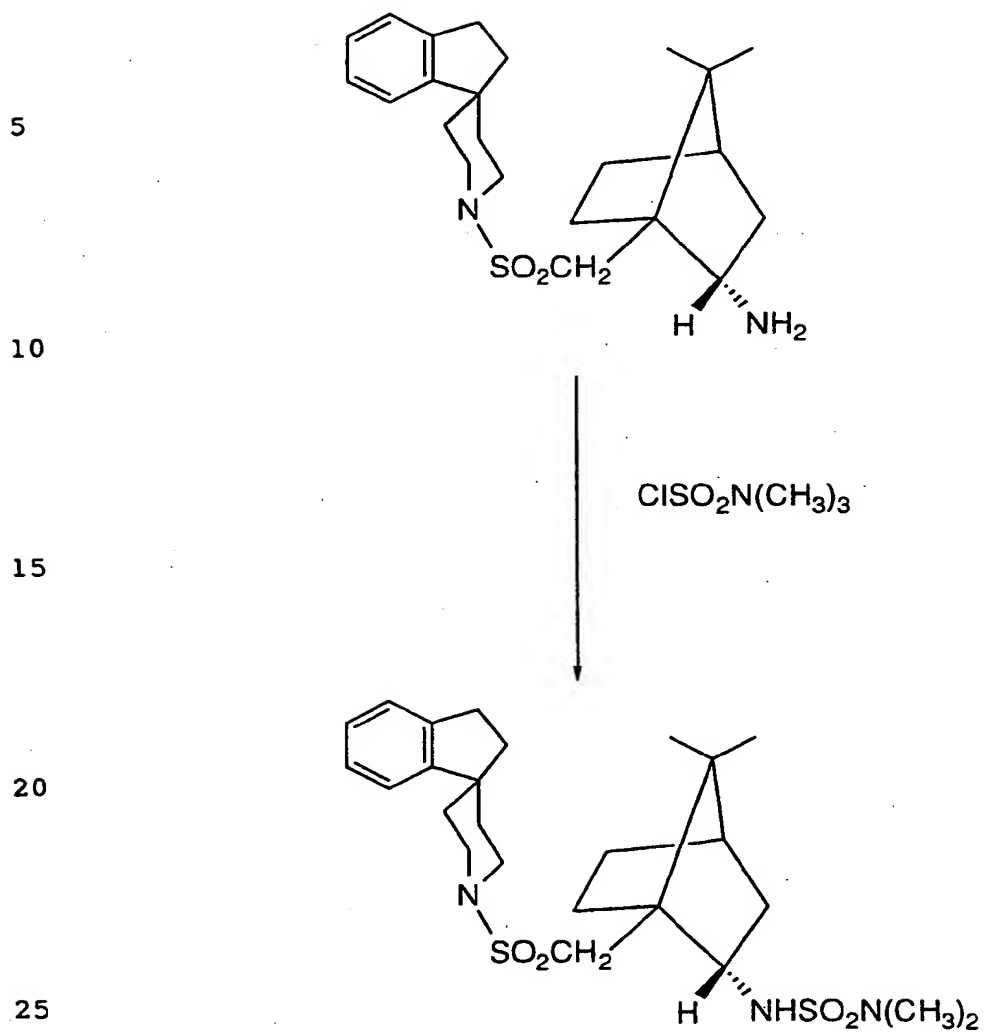
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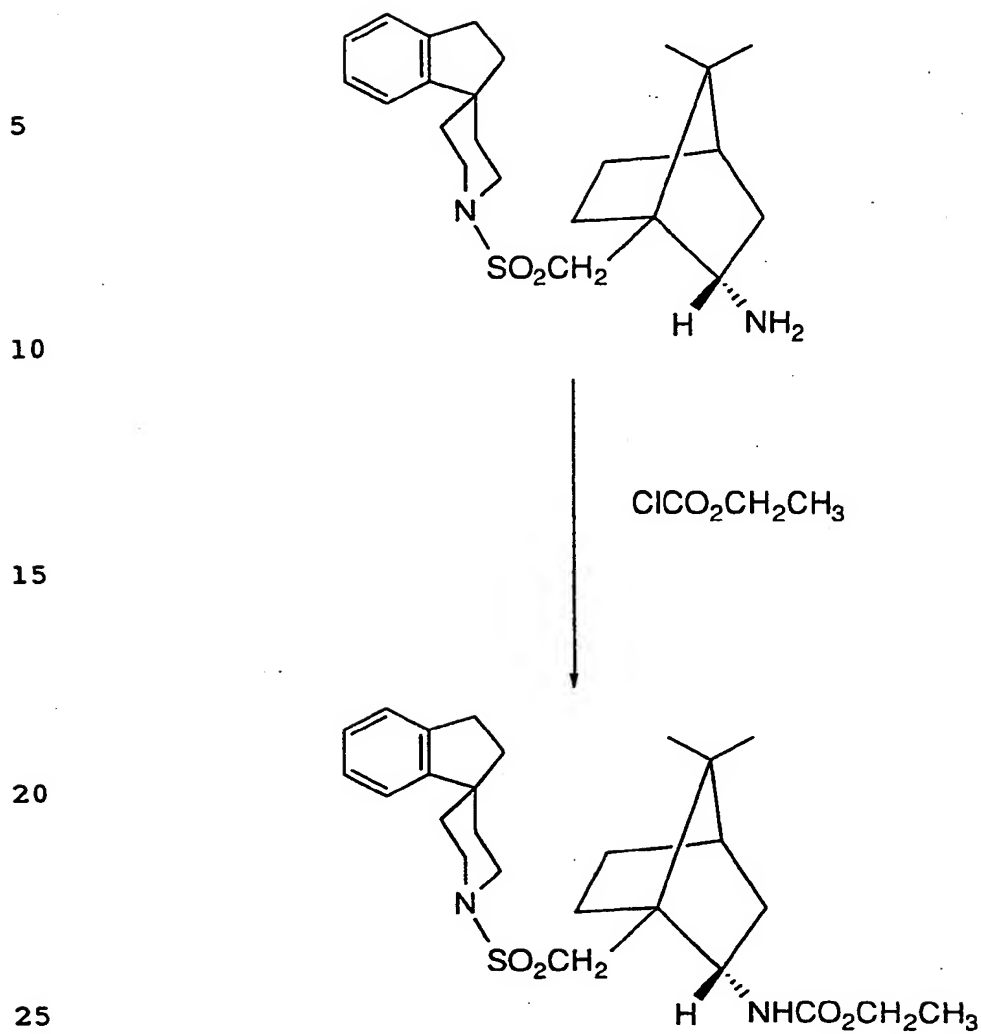
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EXAMPLE 1

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EXAMPLE 2

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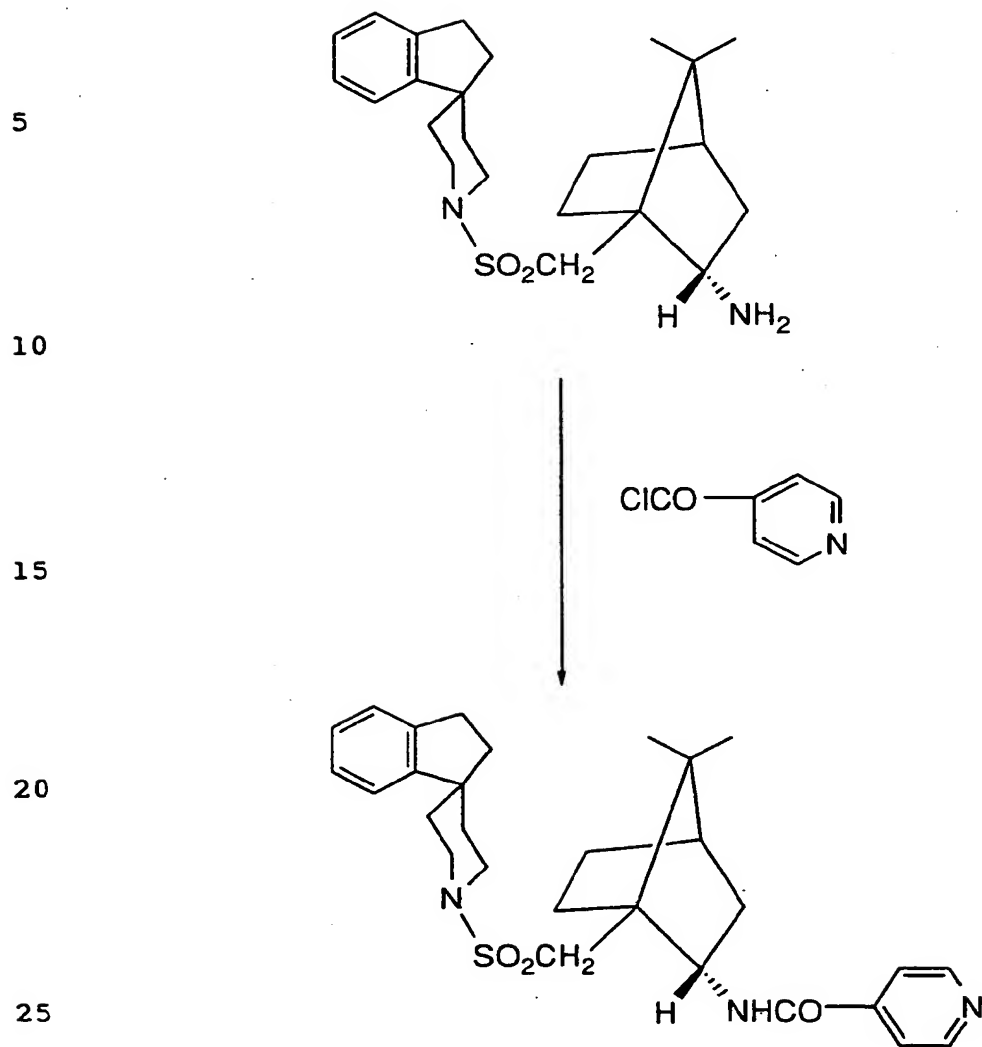
EXAMPLE 3

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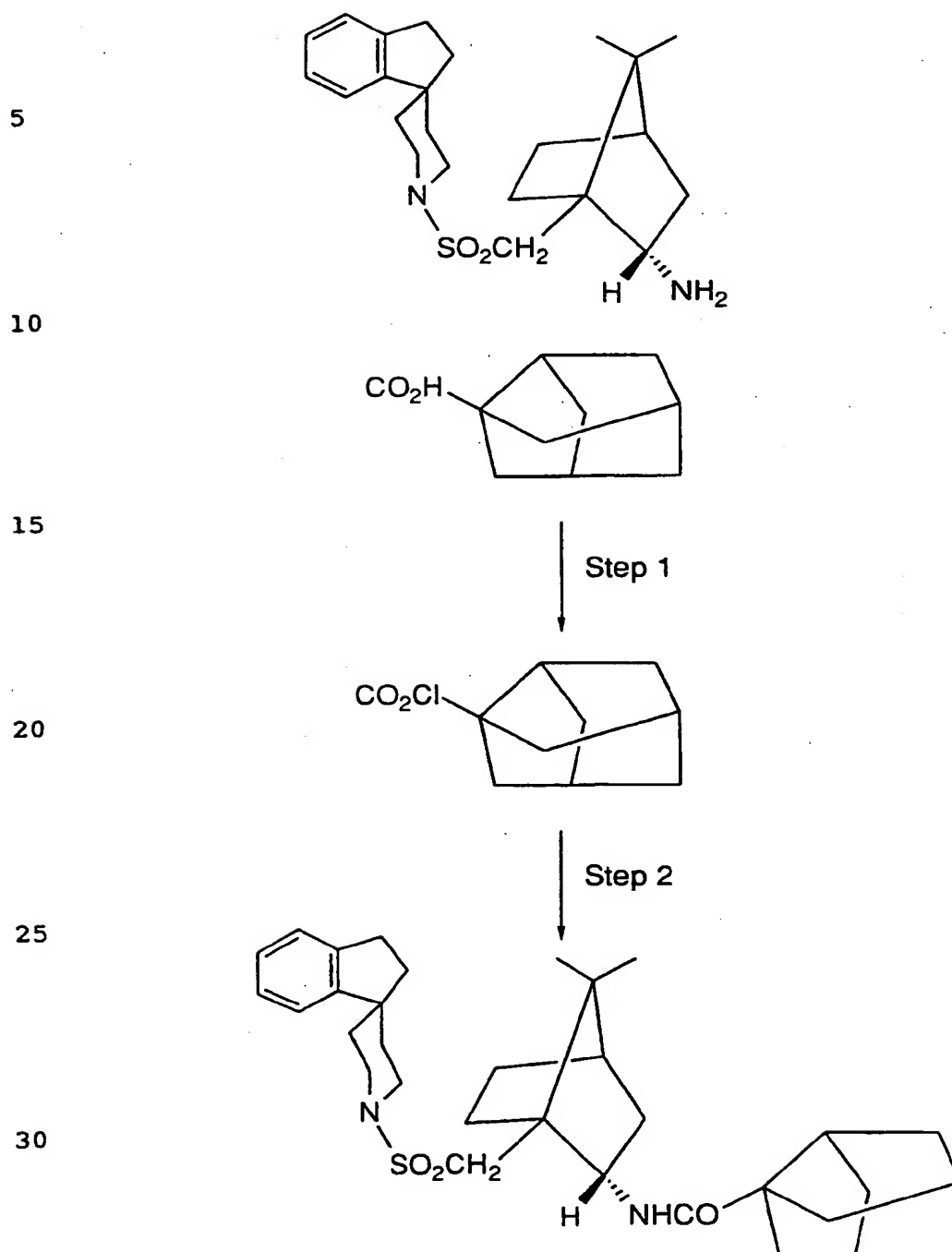


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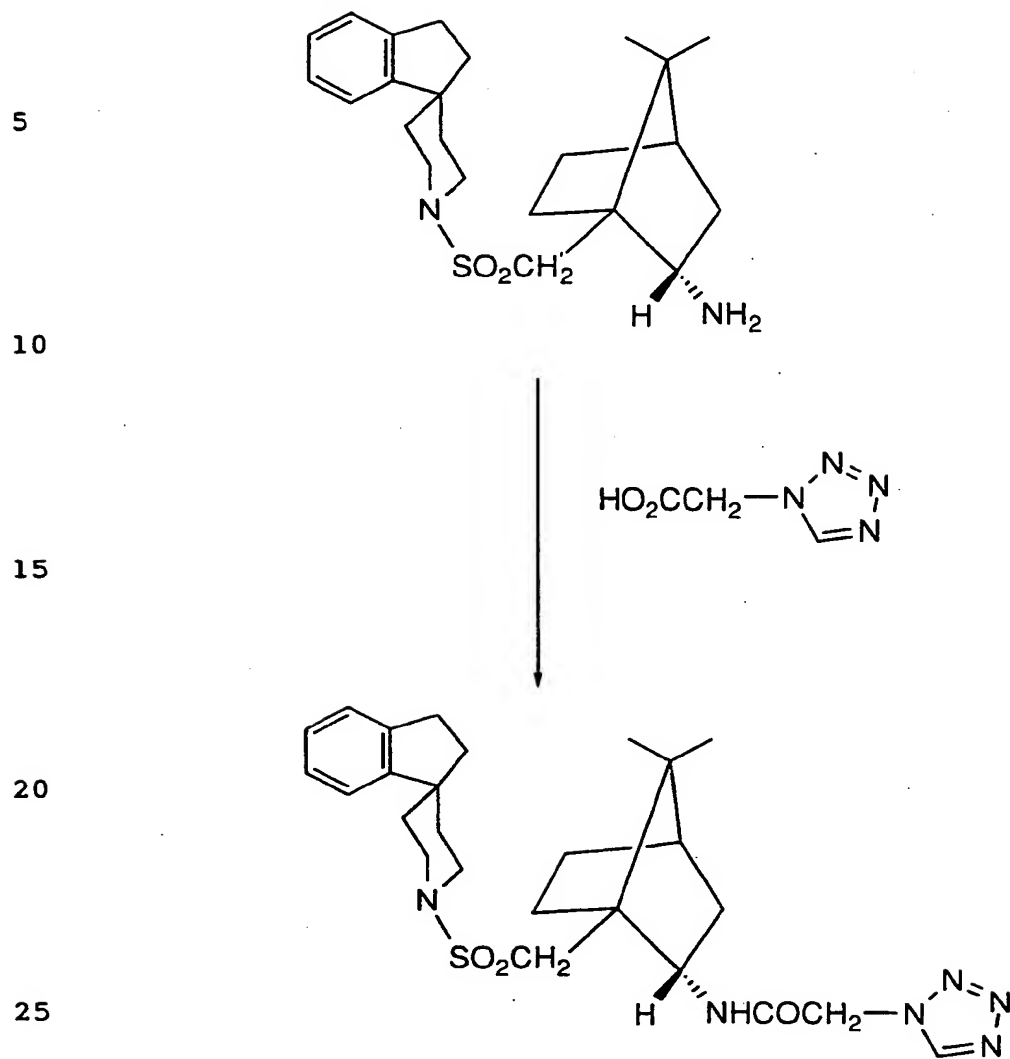
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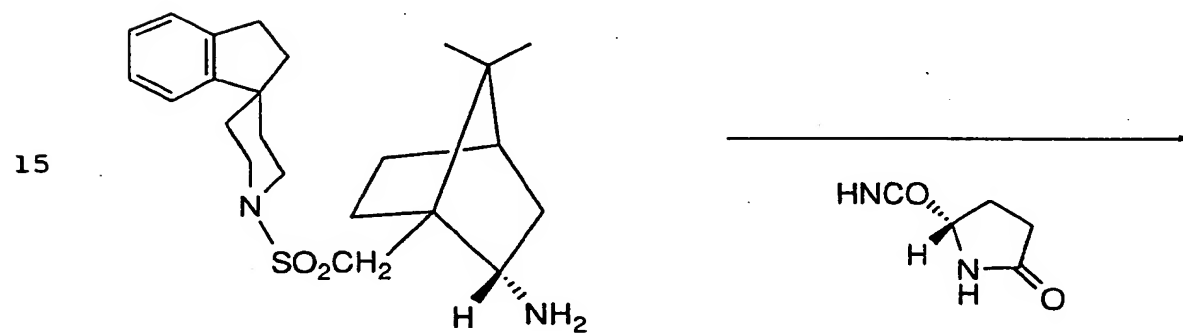
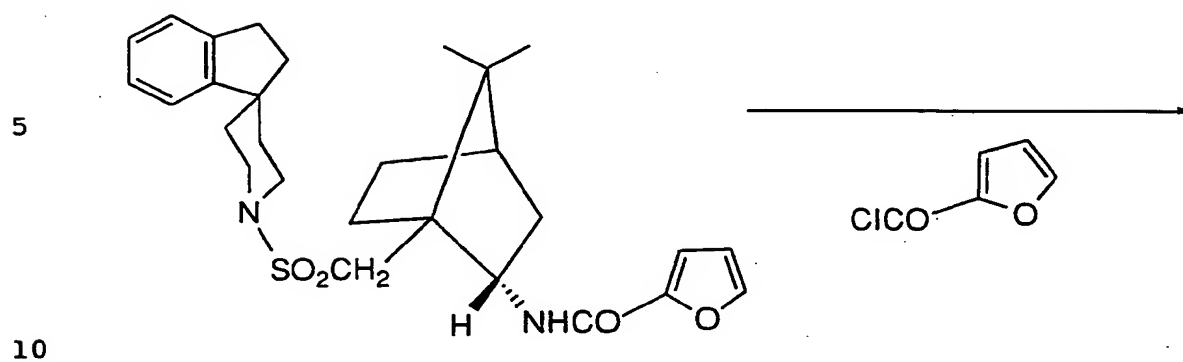
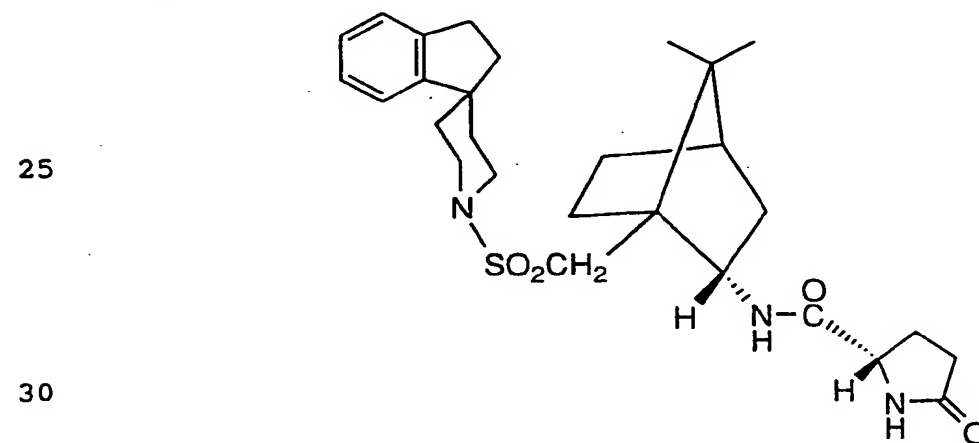
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EXAMPLE 6

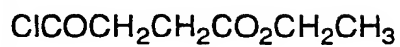
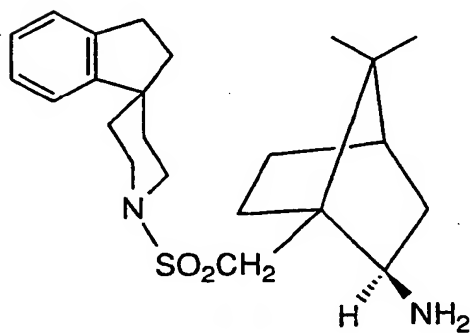
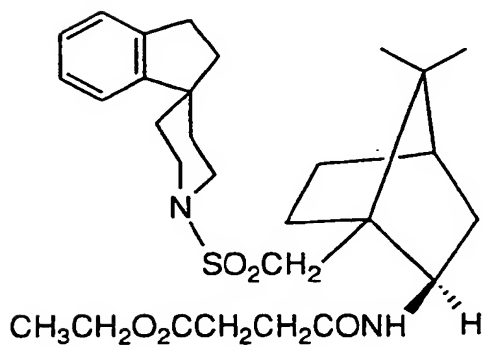
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EXAMPLE 8

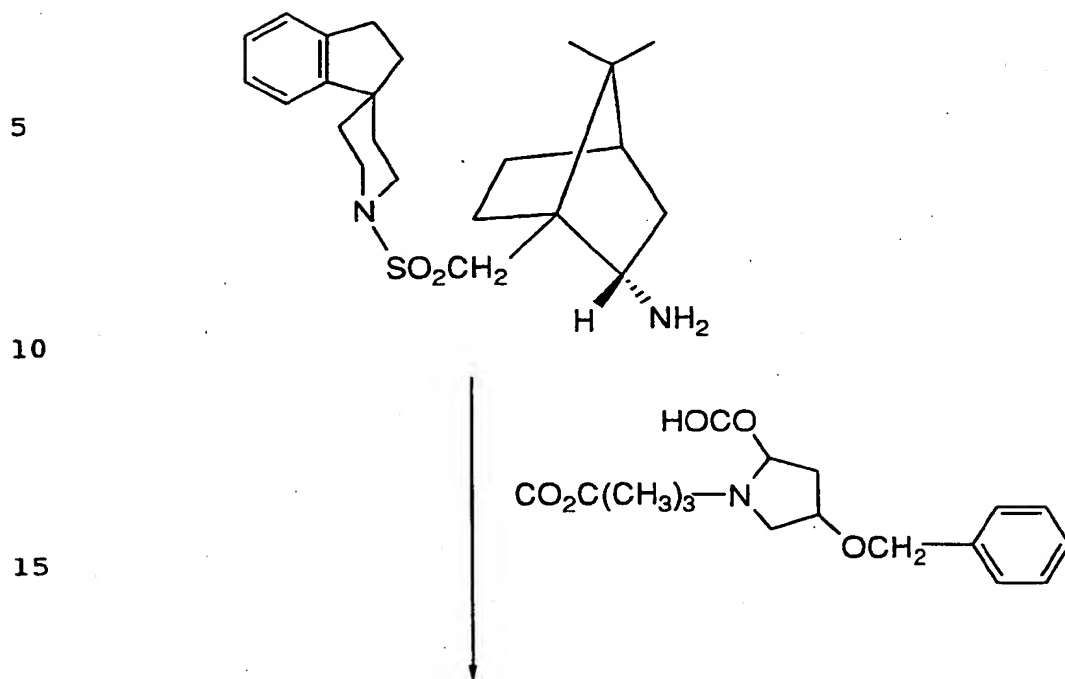
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REACTION SCHEMES, PART 2EXAMPLE 10

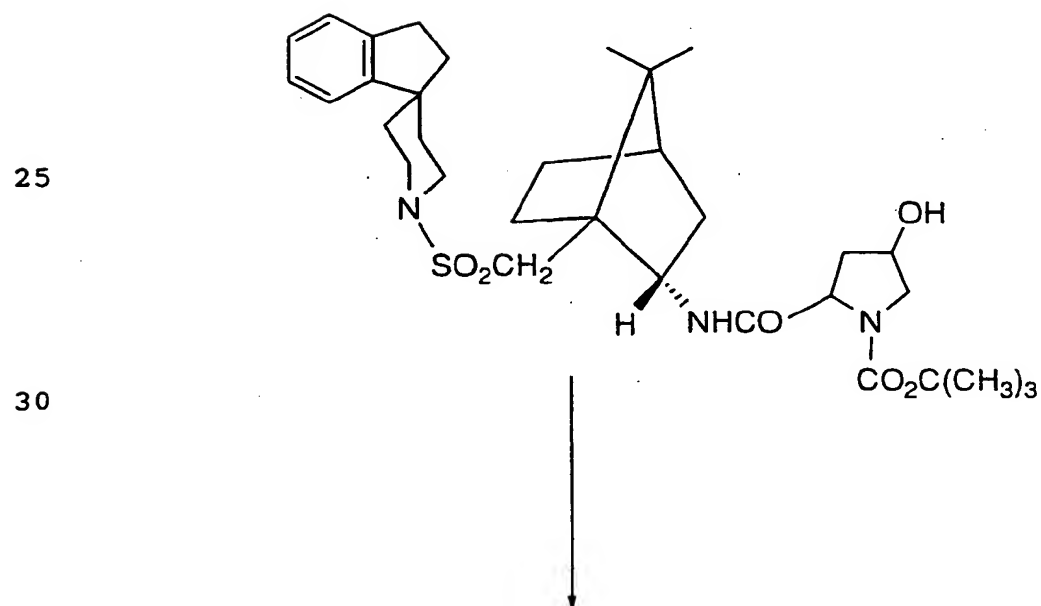
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REACTION SCHEMES, PART 3EXAMPLE 7

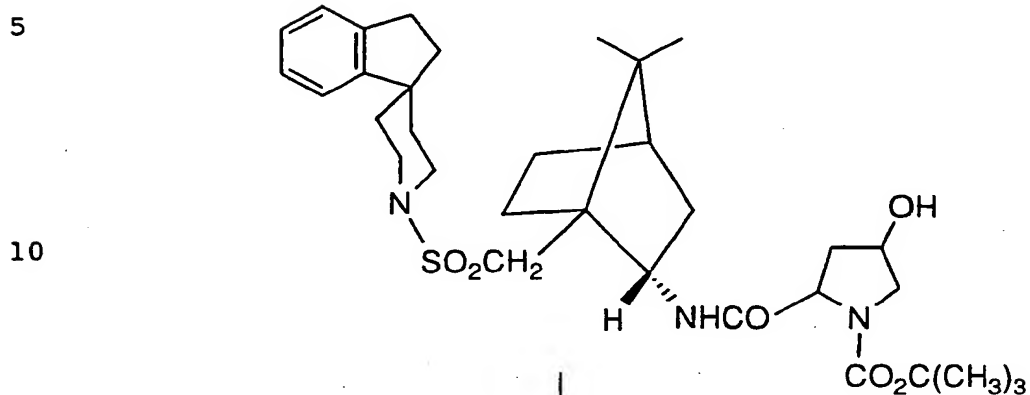
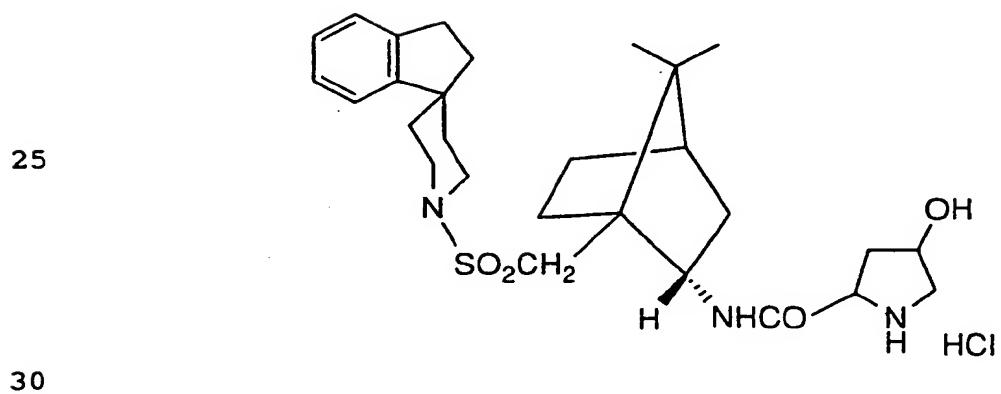
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REACTION SCHEMES, PART 3 CONT'D

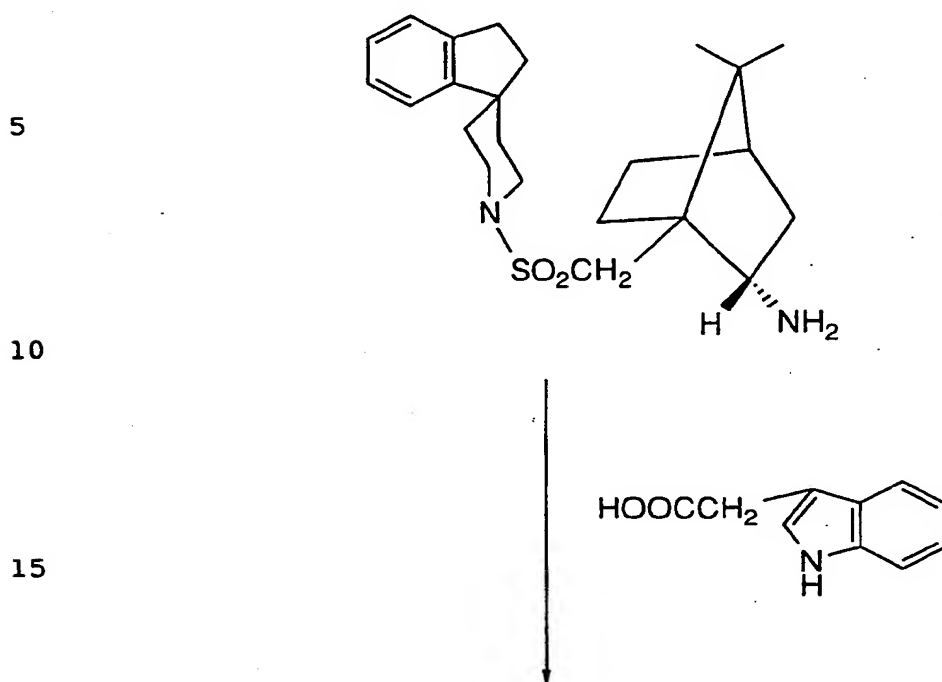
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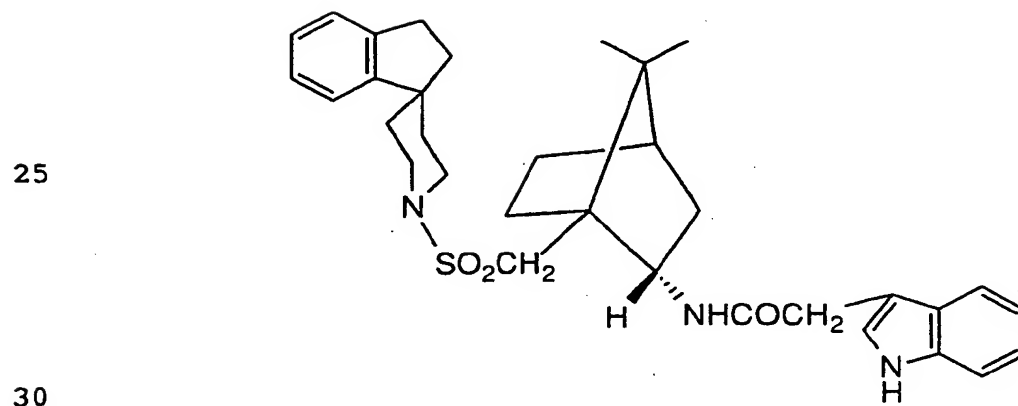
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REACTION SCHEMES, PART 3 CONT'DEXAMPLE 12EXAMPLE 13

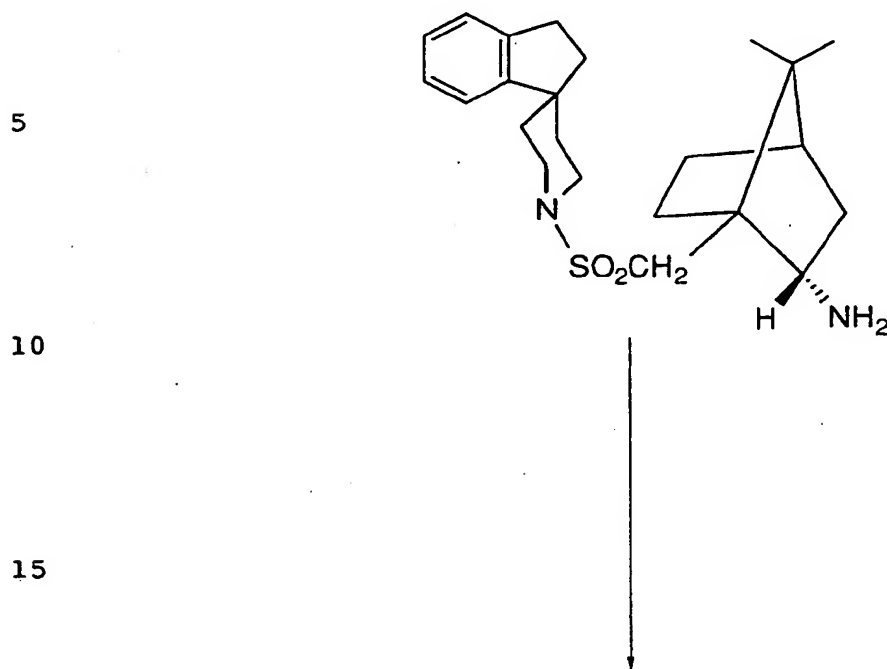
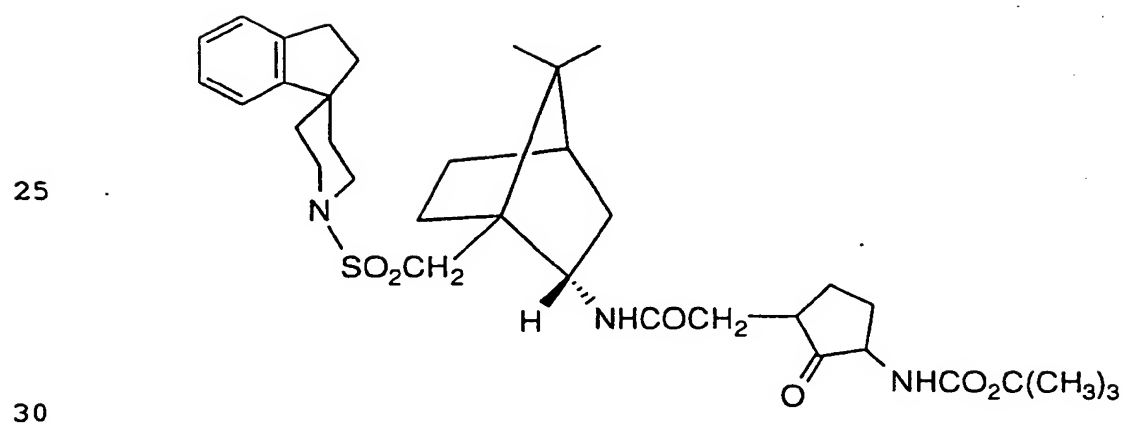
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REACTION SCHEMES, PART 3 CONT'D

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EXAMPLE 14

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REACTION SCHEMES. PART 4EXAMPLE 15

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REACTION SCHEMES, PART 4 CONT'D

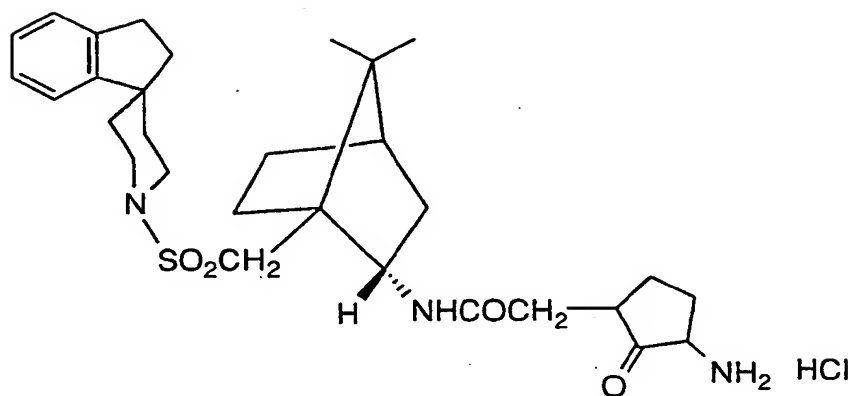
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EXAMPLE 16

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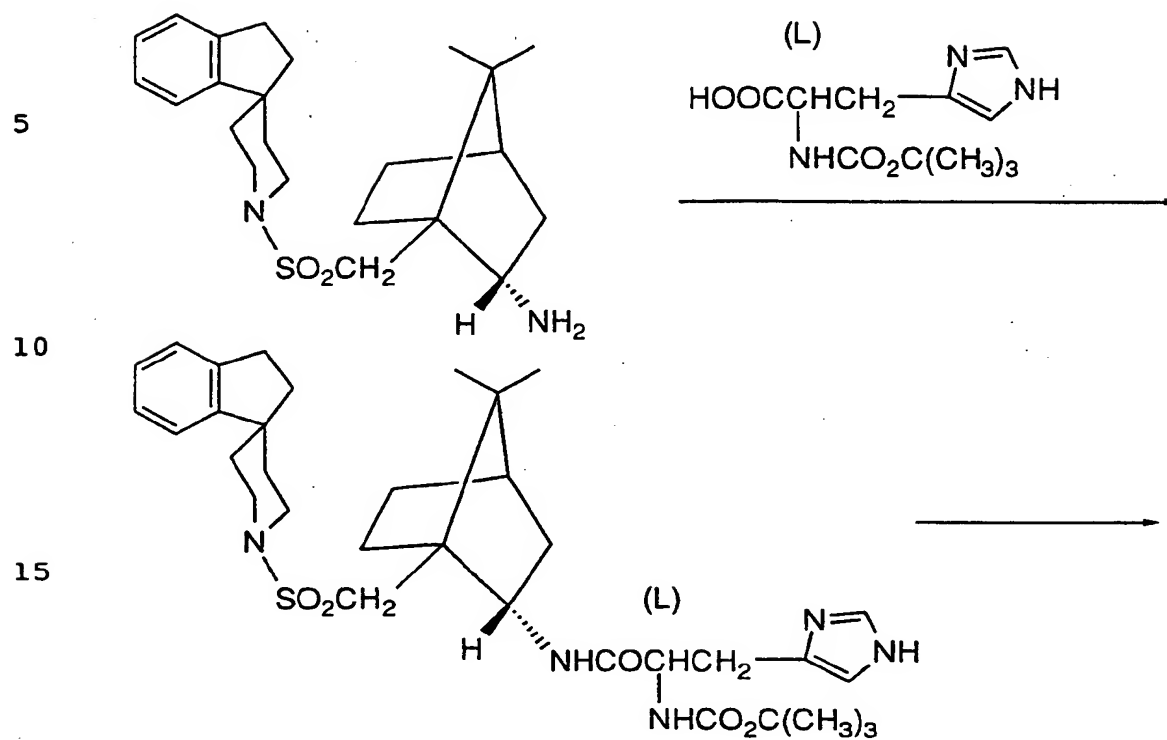
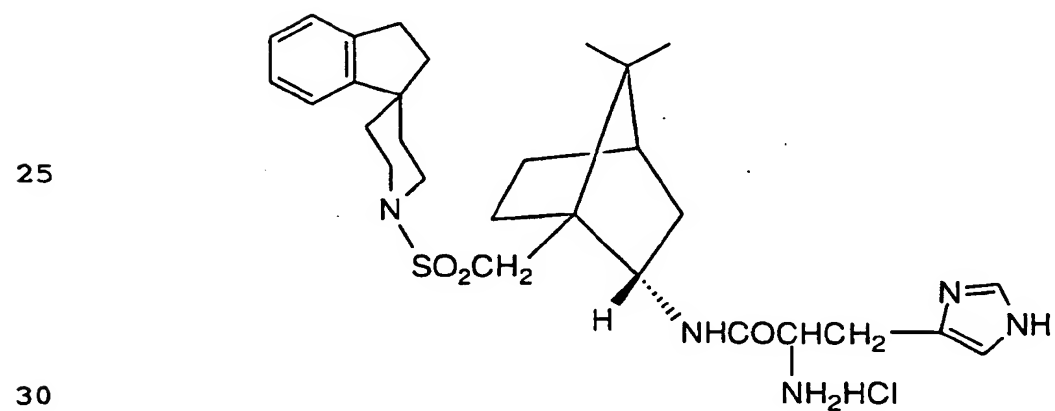
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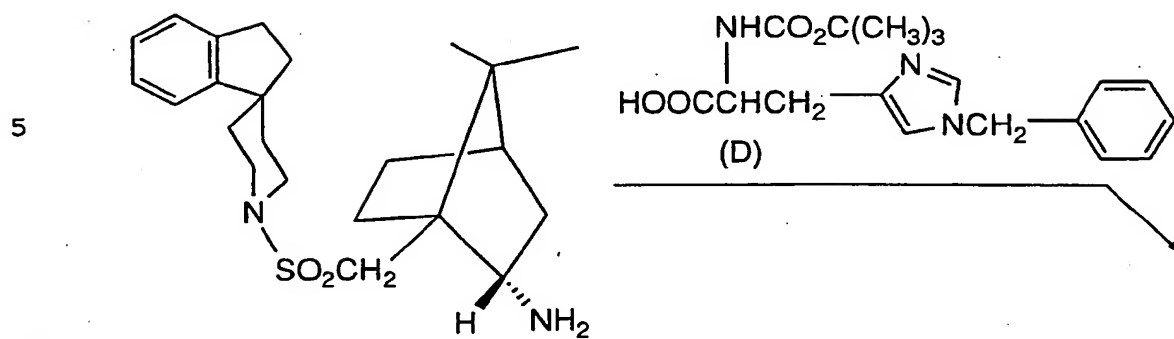
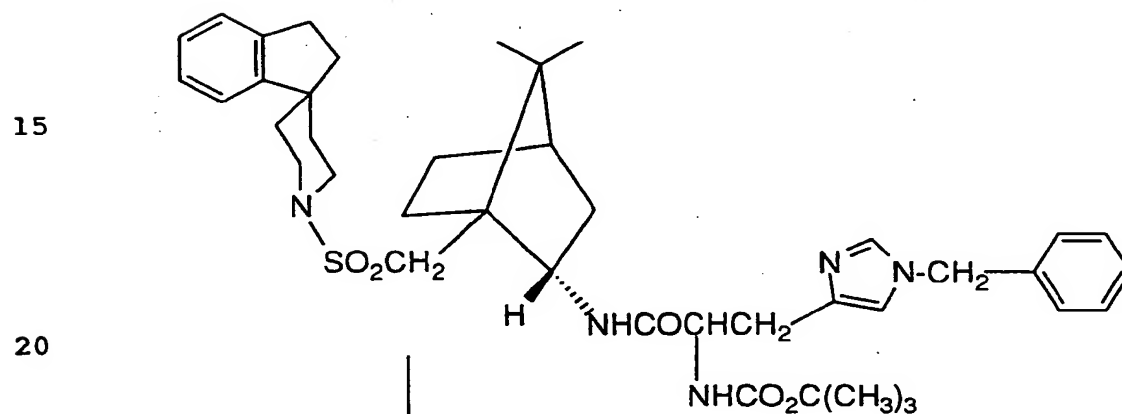
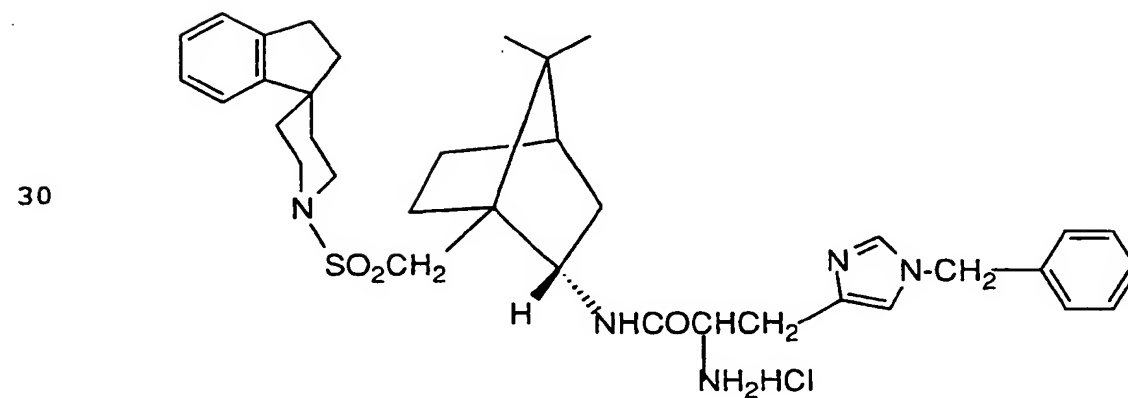
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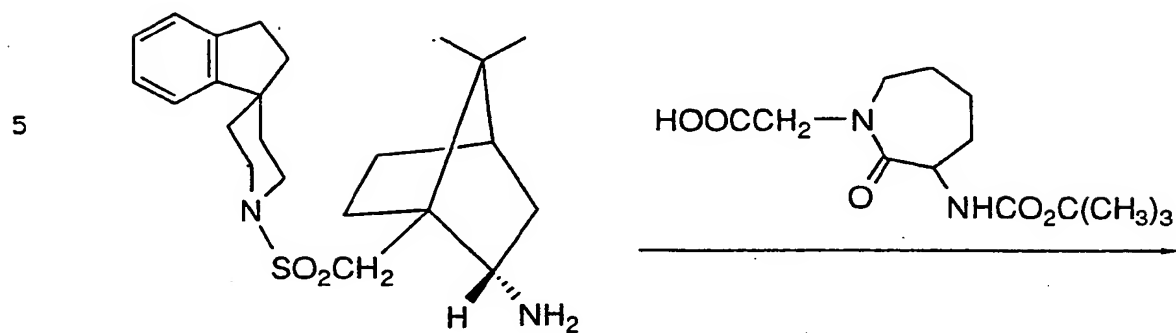
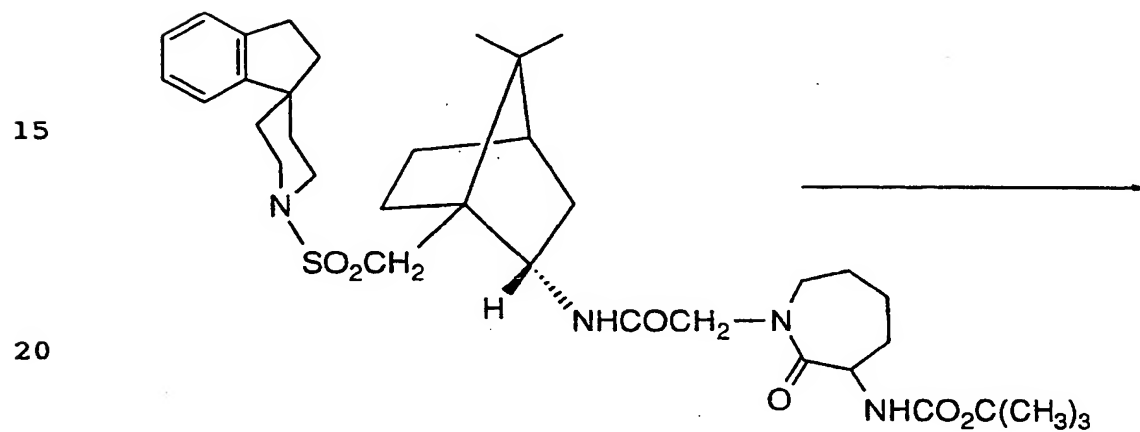
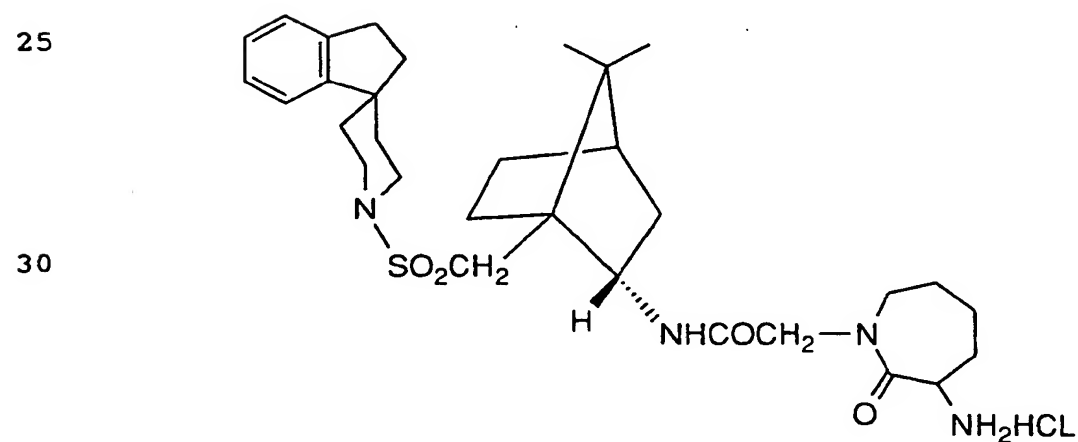
- 48 -

REACTION SCHEMES, PART 5EXAMPLE 17

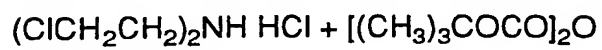
- 49 -

REACTION SCHEMES, PART 5 CONT'DEXAMPLE 18EXAMPLE 19

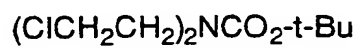
- 50 -

REACTION SCHEMES, PART 6EXAMPLE 20EXAMPLE 21

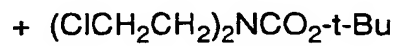
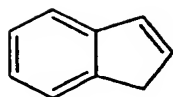
- 51 -

REACTION SCHEMES, PART 7

5

 Et_3N 

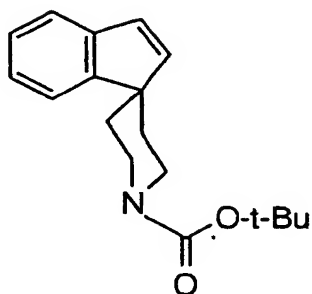
10



15

 $\text{LiN}[\text{Si}(\text{CH}_3)_3]_2$

20

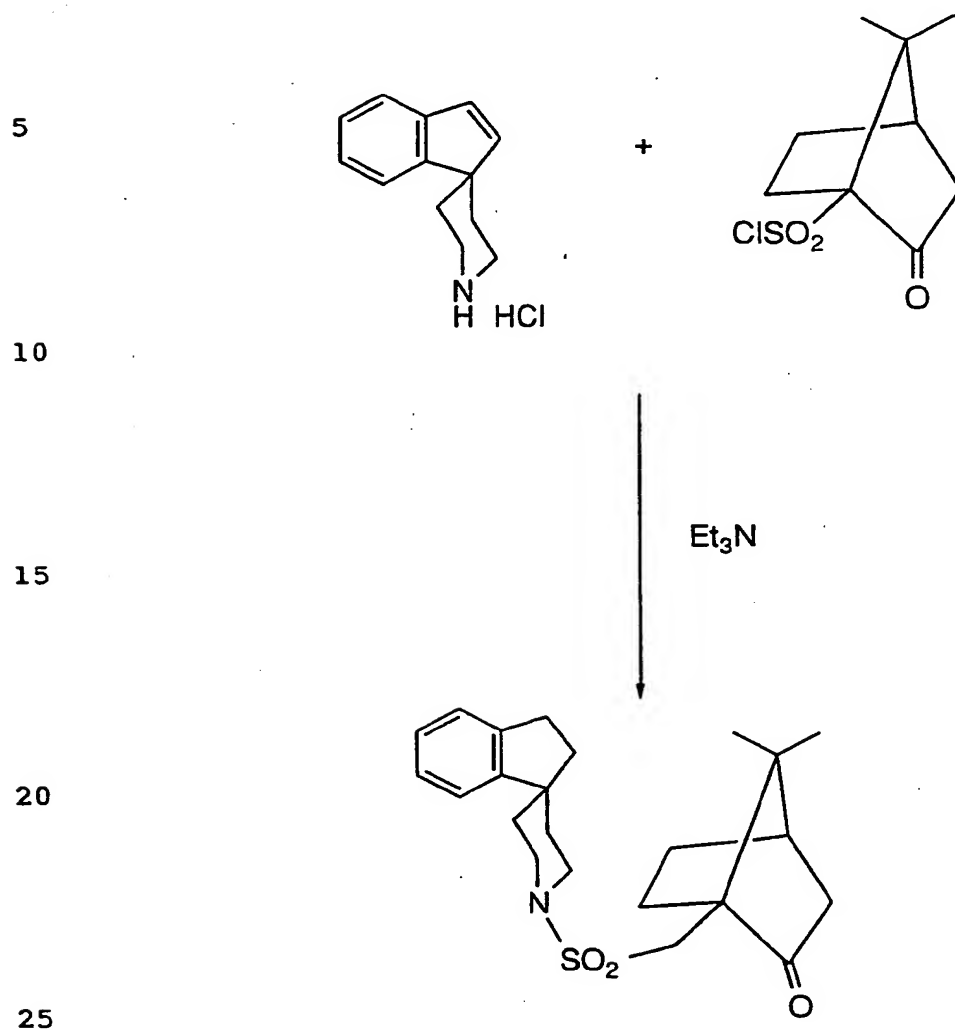


25

 HCl, EtOAc

30

- 52 -

REACTION SCHEMES, PART 7 CONT'D

- 53 -

REACTION SCHEMES, PART 7 CONT'D

5

H₂NOH HCl
pyridine

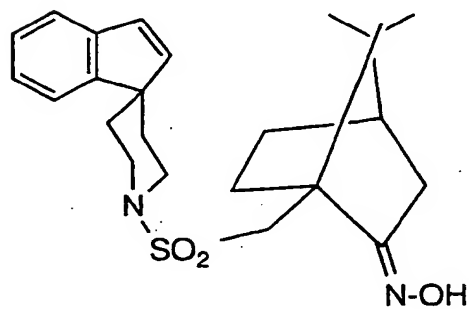
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15

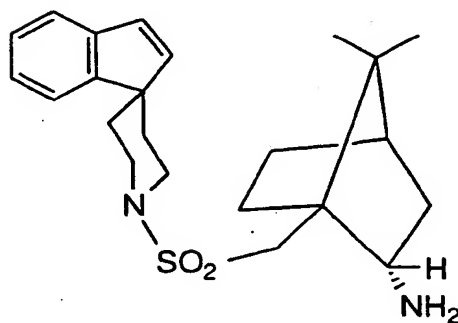
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25

30



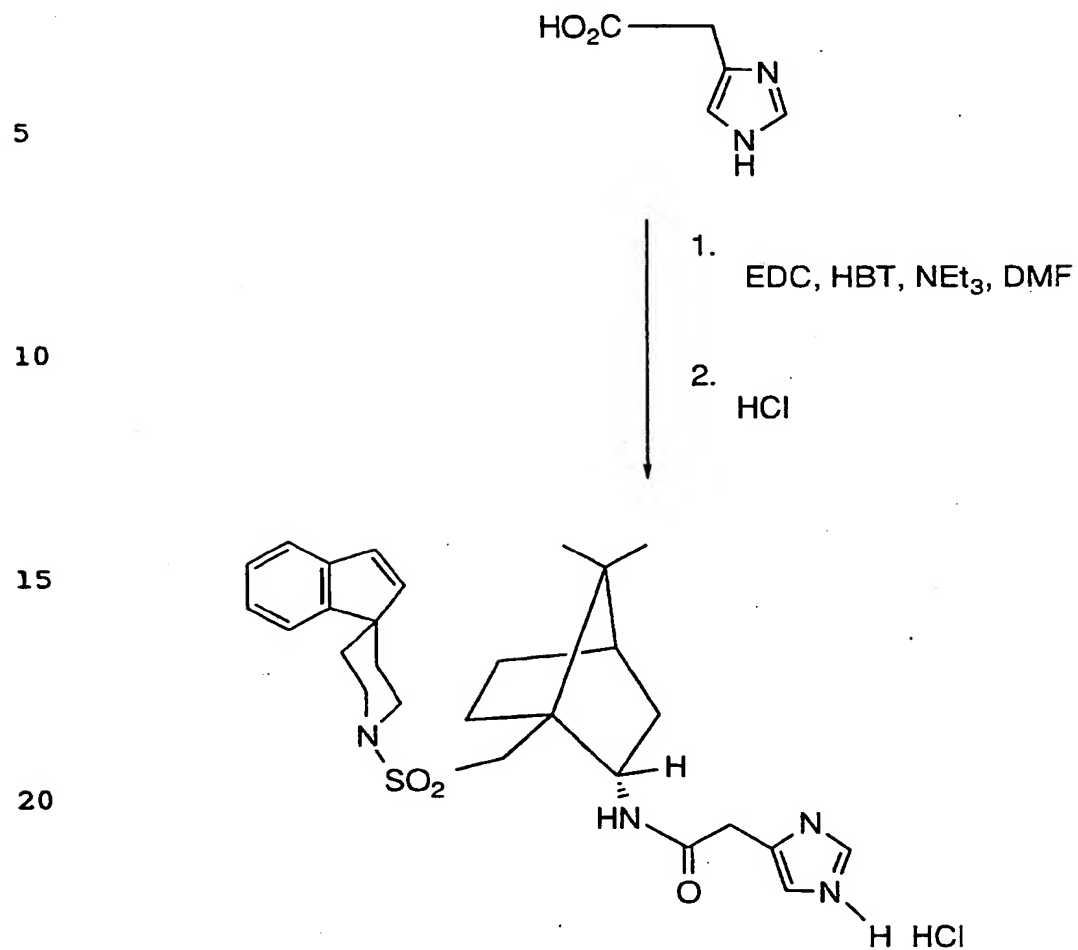
Ni(R), H₂



+

Endo Isomer

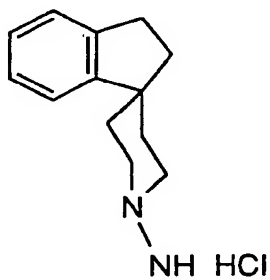
- 54 -

REACTION SCHEMES, PART 7 CONT'D

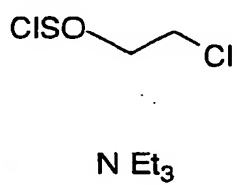
- 55 -

REACTION SCHEMES, PART 8

5



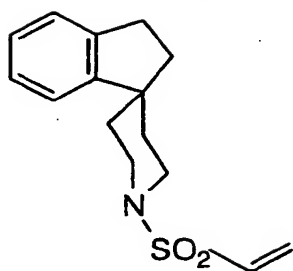
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15



20



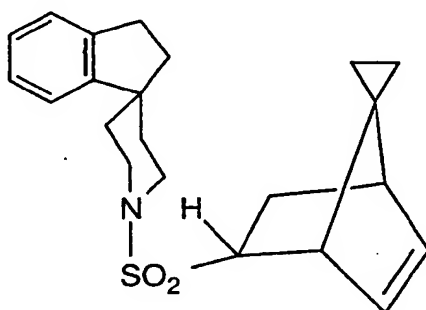
25



30

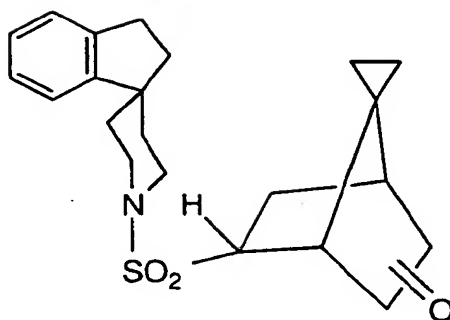


- 56 -

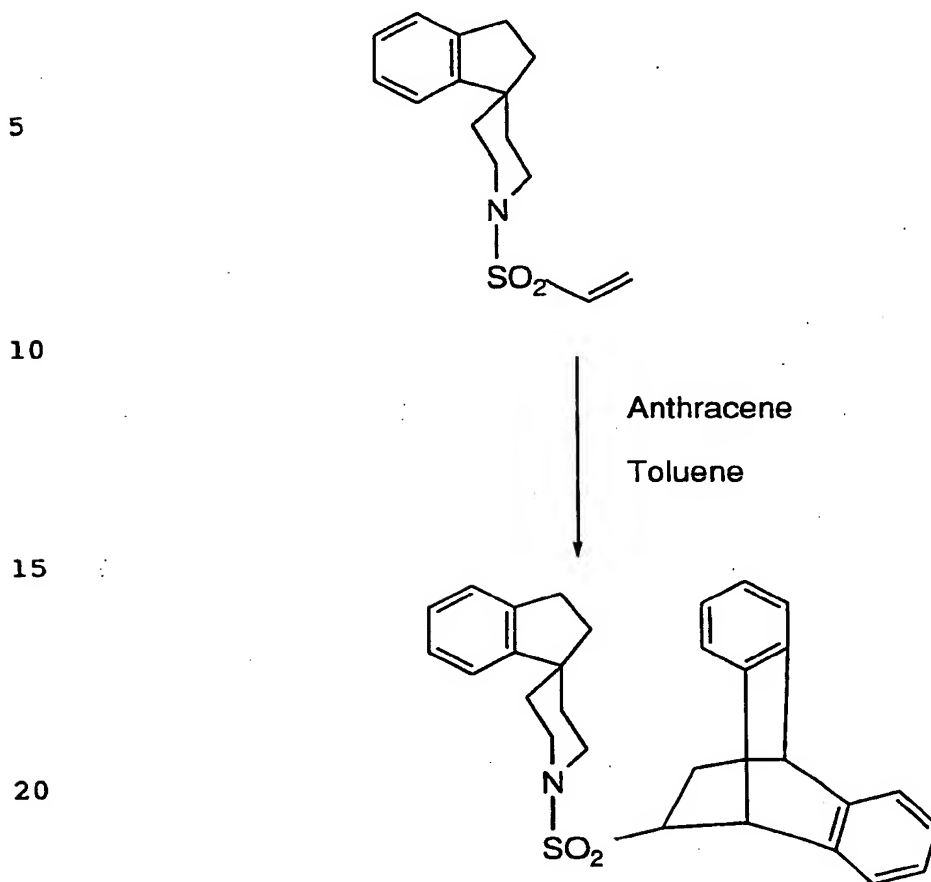
REACTION SCHEMES, PART 8 CONT'D

+ TRACE OF EXO ISOMER

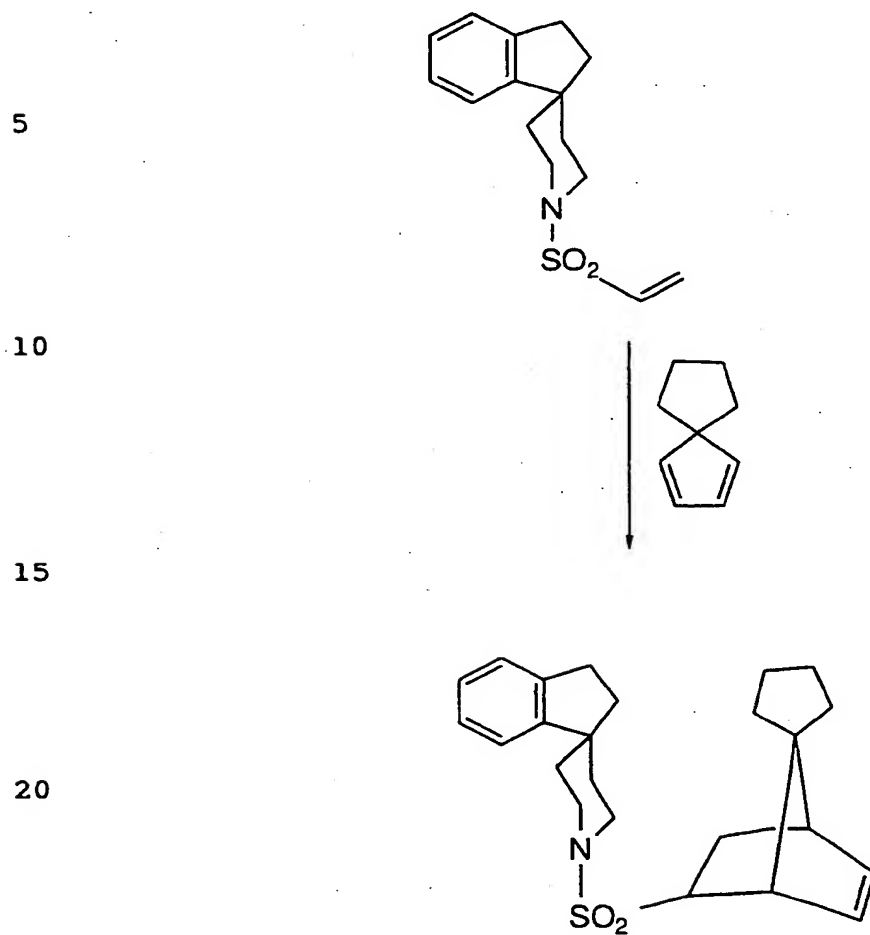
1. BH_3 THF
 H_2O_2 , OH
2. pyridinium
chlorochromate,
 CH_2Cl_2

EXAMPLE 31

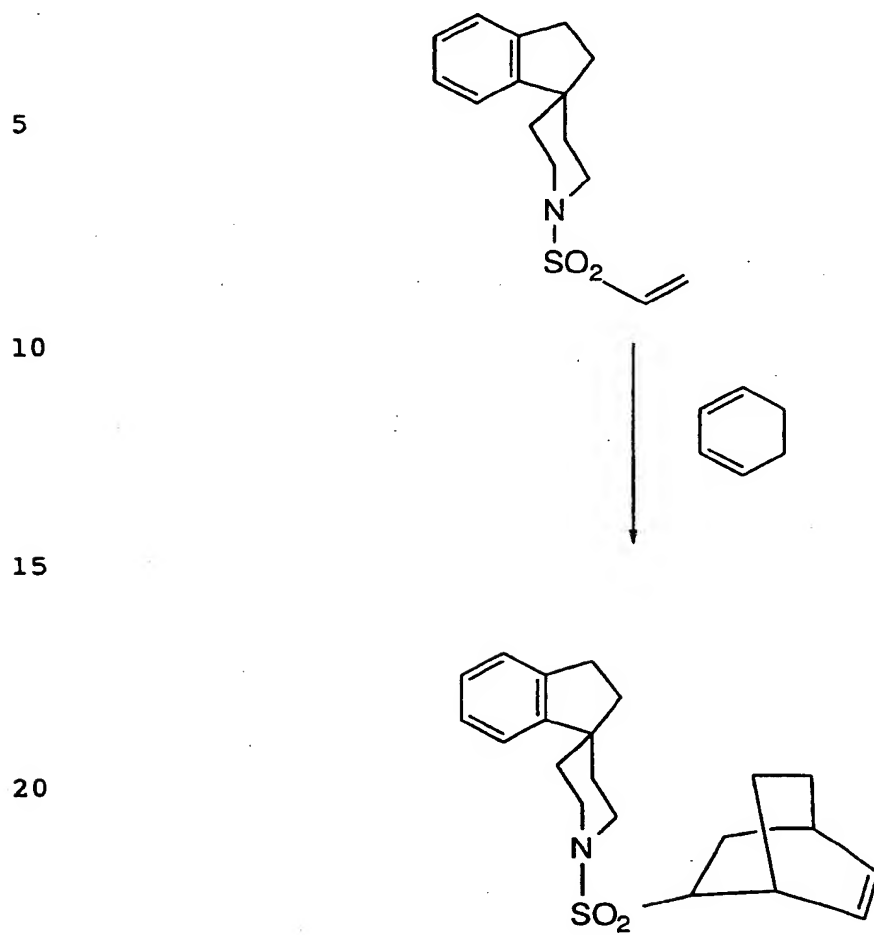
- 57 -

REACTION SCHEMES, PART 8 CONT'DEXAMPLE 32

- 58 -

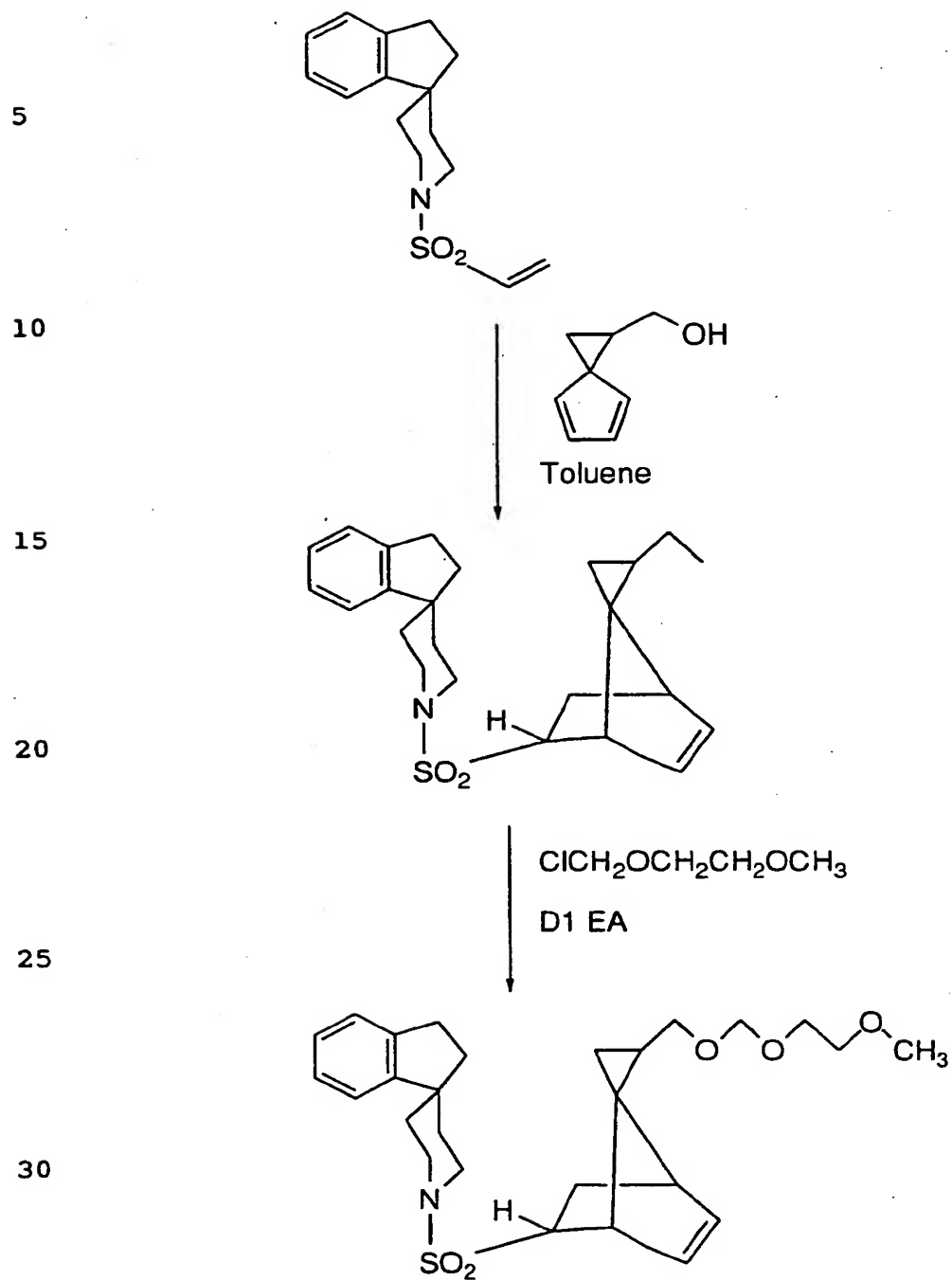
REACTION SCHEMES, PART 8 CONT'DEXAMPLE 33

- 59 -

REACTION SCHEMES, PART 8 CONT'DEXAMPLE 34

- 60 -

REACTION SCHEMES, PART 9

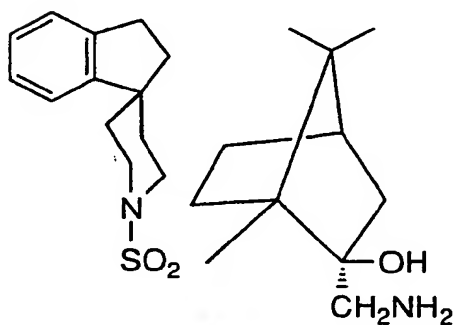


EXAMPLE 35

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REACTION SCHEMES, PART 10

5

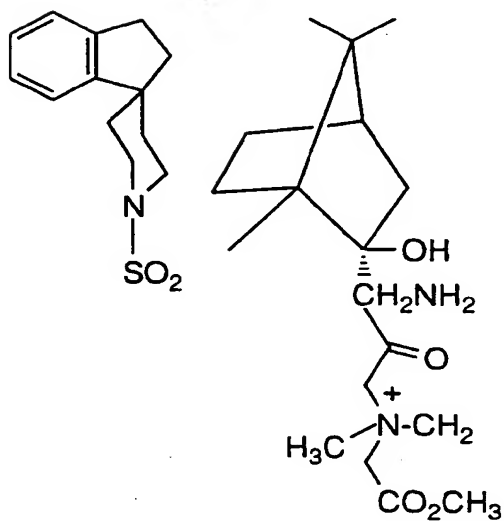


10

1. Methyliminodiacetic acid
anhydride, toluene
THF

2. CH₃I, DMF

15



20

25

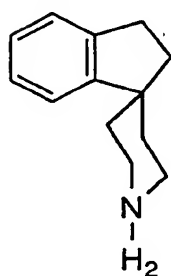
EXAMPLE 36

30

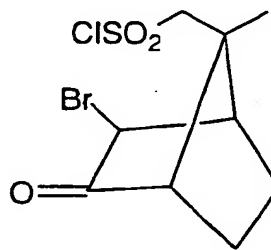
- 62 -

REACTION SCHEMES, PART 11

5

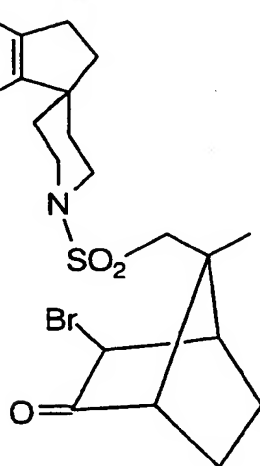


10



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EXAMPLE 37

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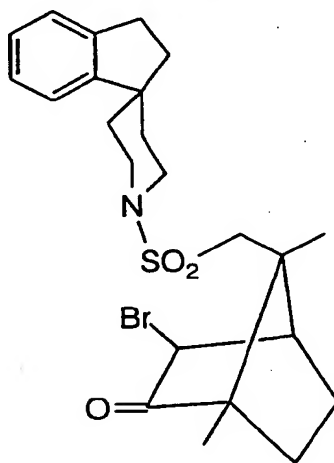
REACTION SCHEMES, PART 11 CONT'D

5

Zn - HOAc

10

15



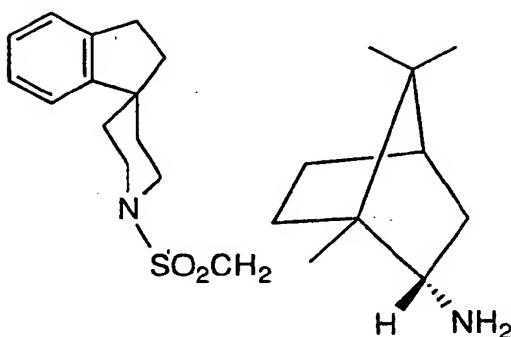
20

EXAMPLE 38

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EXAMPLE A

Endo-(1S)-1'(((2-amino-7,7-dimethylbicyclo(2.2.1)-hept-1-yl)-methyl)-sulfonyl)spiro(1H-indan-1,4'-piperidine)

Di-*t*-butyl dicarbonate (31g, 0.14 mole available from Aldrich) and bis(2-chloroethyl)amine hydrochloride (21.6g, 0.12 mole Aldrich) were combined in CH₂Cl₂ (250 ml) stirred at ambient temperature and treated with triethylamine (12.8 g, 0.127 mole) added dropwise over 15 minutes. After 1 hour, another 1.5 ml of triethylamine was added. After a total of 2.5 hours, the mixture was poured onto a silica gel column packed with CH₂Cl₂:hexane (1:1), and eluted with CH₂Cl₂. The combined product fractions were evaporated to dryness in vacuo to give N,N-bis(2-chloroethyl)-*t*-butylcarbamate.

To a solution of indene (10.3 g, 89 mmole) in dry tetrahydrofuran (THF, 18 ml) cooled in an ice bath and maintained under a nitrogen blanket was added lithium bis(trimethylsilyl)amide (Aldrich, 177 ml of a 1.0M solution in THF; 177 mmole) over 15 minutes. The mixture was stirred in the cold for 30 minutes, then added over 15 minutes to a solution of N,N-bis(2-chloroethyl)-*t*-butylcarbamate (21.2 g, 88 mmole) stirred in an ice bath. The mixture was stirred for 2 hours in the cold and for 30 minutes at ambient temperature under nitrogen, then evaporated in vacuo to a foam. CH₂Cl₂ was added and the resulting mixture poured onto a silica gel column packed with 40% hexane in CH₂Cl₂. The column

- 65 -

was eluted with 40% hexane in CH₂Cl₂ followed by CH₂Cl₂, and the product fractions were evaporated to dryness in vacuo to provide 1'-(t-butyloxycarbonyl)-spiro(indene-1,4'-piperidine).

5 1'-(t-Butyloxycarbonyl)spiro(indene-1,4'-piperidine) (16 g, 56 mmole) in ethyl acetate (250 ml) was stirred in an ice bath and saturated with HCl(g) for 30 minutes. The mixture was evaporated to dryness. Ethyl acetate was added and removed in vacuo three times, and the residue was triturated with diethyl ether and filtered to provide spiro(1H-indene-1,4'-piperidine) hydrochloride. The free base was
10 obtained by slurrying the hydrochloride in aqueous sodium bicarbonate solution and extracting with CH₂Cl₂. The organic layer was separated, dried over sodium sulfate, filtered, and evaporated to dryness in vacuo to provide spiro(1H-indene-1,4'piperidine).

15 Spiro(1H-indene-1,4'piperidine) (308 mg, 1.66 mmol) and (+)-10-camphorsulfonyl chloride (418 mg, 1.66 mmol) were combined in CH₂Cl₂ and treated with triethylamine (0.23 ml). The mixture was stirred at ambient temperature for 15 minutes, then poured onto a silica gel column and eluted with 1:1 CH₂Cl₂:hexane. The product fractions were combined and evaporated to dryness in vacuo to provide (1S)-1'-
20 (((7,7-dimethyl-2-oxobicyclo-(2.2.1) hept-1-yl)-methyl)sulfonyl)spiro(1H-indene-1,4'-piperidine) as a solid which was recrystallized from petroleum ether and dried overnight in vacuo at ambient temperature.

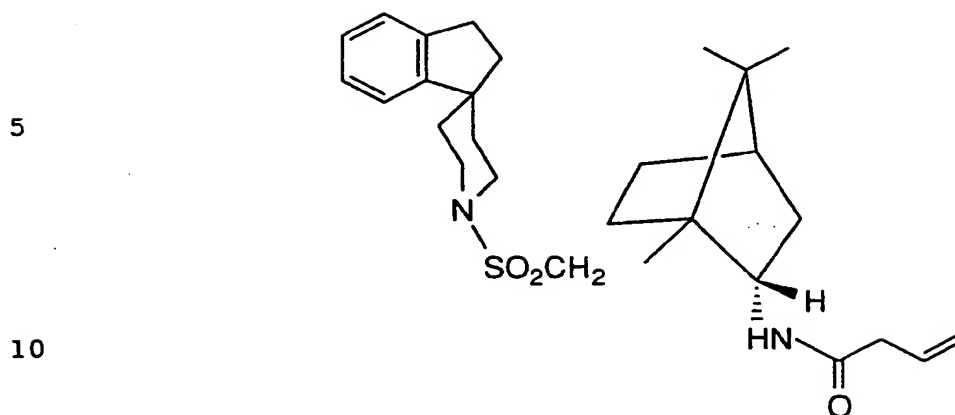
(1S)-1'-(((7,7-dimethyl-2-oxobicyclo(2.2.1)hept-1-yl)methyl)sulfonyl)spiro(1H-indene-1,4'-piperidine) (30 g, 0.075 mole)
25 in pyridine (500 mL) was heated in an oil bath to 70°C (internal). Hydroxylamine hydrochloride (30 g) was added in three portions over ca. 20 minutes. After 2 hours, an additional 10 g of hydroxylamine hydrochloride was added (over 10 minutes). At 30, 40, and 50 minutes additional elapsed time, further 3 g lots of hydroxyl-amine
30 hydrochloride were added. After another 30 minutes, the mixture was poured into water (2 L) and extracted 3 times with ethyl acetate (300 mL portions). The organic layers were combined, washed with 1N HCl (600 mL total), dried over sodium sulfate, filtered, and evaporated to dryness in vacuo. EtOH (abs; ca. 250 mL) was added to the resulting

- 66 -

thick syrup and the solution allowed to stand at ambient temperature overnight. The mixture was filtered and the filtrate boiled down to ca. 80 mL. After standing, the mixture was again filtered and boiled down to ca. 20 mL. After a third filtration, the filtered solids were combined to give (1S)-1'-(((7,7-dimethyl-2-oximinobicyclo(2.2.1)hept-1-yl)-methyl) sulfonyl)spiro(1H-indene-1,4'-piperidine) (28 g).

Freshly prepared, activated Raney Nickel catalyst (ca. 30 g) in water was allowed to settle and the water decanted. Abs. ethanol (300 mL) was added, and the mixture swirled and again allowed to settle. The solvent was decanted. Two more wash-decant cycles with 150 mL of ethanol were similarly carried out. (1S)-1'-(((7,7-dimethyl-2-oximinobicyclo(2.2.1)hept-1-yl)methyl)sulfonyl)-spiro(1H-indene-1,4'-piperidine) (30 g) was stirred in a mixture of abs. ethanol (450 mL) and 2-methoxyethanol (900 mL), nitrogen was bubbled through the suspension/solution, and the Raney Nickel catalyst was added. The mixture was hydrogenated under 50 psi overnight. TLC (9:1 CH₂Cl₂MeOH, silica gel) showed the reaction to be complete. The catalyst was removed by filtration, and the filtrate evaporated to dryness in vacuo. The crude solid (27 g) was divided into 7 g batches, and each batch was dissolved in methylene chloride (ca. 200 mL) and flash chromatographed on silica (700 g in a 100 mm column, packed and eluted with 8% (v/v) methanol in methylene chloride), taking 200 mL fractions. The exo isomer of the title amine was obtained in fractions ca. 5-7, and the desired endo isomer in fractions ca. 8-16. TLC was on silica, eluted with 8% methanol-methylene chloride, phosphomolybdic acid stain. The combined product fractions were evaporated to dryness to provide the title compound (4.5 g from each 7 g lot, ca. 18 g total) as a colorless solid.

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EXAMPLE 1

Endo-(1S)-1'-(((2-(but-3-ene-1-ylamino)7,7-dimethyl-bicyclo(2.2.1)-
hept-1-yl)-methyl)sulfonyl)spiro(1H-indan-1,4'-piperidine)

15 To a solution of endo-1S-1'-(((2-amino-7,7-dimethyl-
bicyclo(2.2.1.)-hept-1-yl)-methyl)-sulfonyl)spiro(1H-indan-1,4'-
piperidine) (50 mg, 0.000125 m) in methylene chloride (3 ml) in an
atmosphere of nitrogen was added crotonyl chloride (13.1 mg, 14 ml,
0.000125 M) via a syringe. After two minutes, triethylamine (50 ml)
20 was added to make the solution basic (ph=9). After 1 hour, the reaction
mixture was concentrated and the oil was chromatographed on a silica
"flash" column using 40% ethyl acetate in hexane as solvent. Fractions
27-40 contained a fluorescent spot. These were concentrated and ether-
hexane was added and concentrated to yield the title compound
25 as a white foam.

NMR (CDCl₃) was consistent with structure.

HPLC: 210-97.181% 254-99.386%

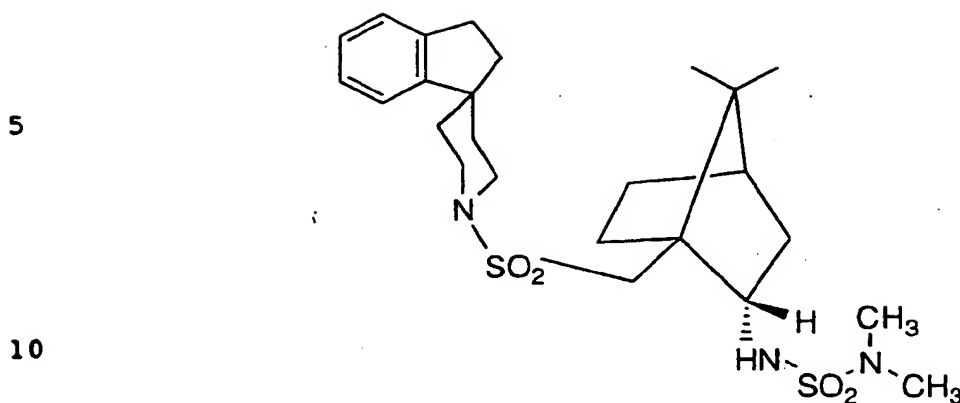
Mass Spectra: Calculated, m/e=470.679; Found, m/e=471.3

30 Analysis calculated for C₂₇H₃₈N₂O₃S

C, 68.90; H, 8.14; N, 5.95

Found: C, 68.99; H, 8.19; N, 5.7

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EXAMPLE 2

15 Endo-(1S)-1'-(((2-(dimethylaminosulfonylamino)-7,7-dimethylbicyclo(2.2.1)-hept-1-yl)-methyl)-sulfonyl)spiro(1H-indan-1,4-piperidine)

In an oven-dried flask (50 ml) under nitrogen was dissolved endo-1S-1'-(((2-amino-7,7-dimethylbicyclo(2.2.1)-hept-1-yl)-methyl)-sulfonyl)-spiro(1H-indan-1,4'-piperidine)(50 mg, 0.000125 M) in methylene chloride (3 ml). Dimethylaminosulfonyl chloride (17.9 mg, 0.000125 M) was added, and after two minutes, triethylamine (50 ml) was added. After one hour, the reaction mixture was concentrated under reduced pressure (20 mm). A silica "flash" column using methylene chloride(9)-methanol(1) as solvents was used to purify the title compound as a tan solid after adding and concentrating with hexane.

NMR (CDCl₃) was consistent with structure.

HPLC: 210-96.47% 254-100%

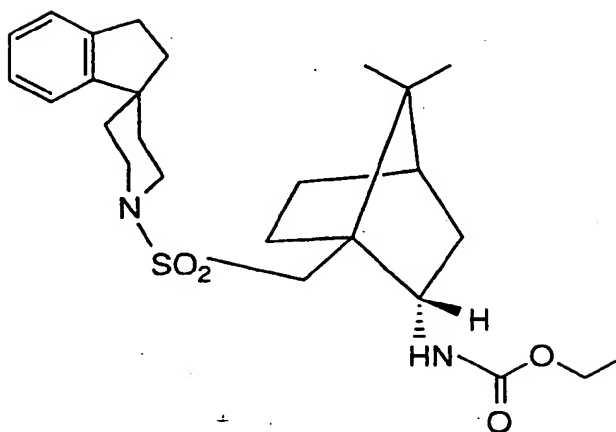
Mass Spectra: Calculated, 509.736; Found, 510.3

Analysis calculated for C₂₅H₃₉N₃O₄S₂

C, 59.51; H, 7.93; N, 8.04

Found: C, 59.58; H, 7.71; N, 7.87

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EXAMPLE 3

Endo-(1S)-1'-(((2-(ethoxycarbonylamino)-7,7-dimethyl-bicyclo-
(2.2.1)-hept-1-yl)-methyl)-sulfonyl)spiro(1H-indan-1,4-piperidine)

In an oven-dried flask (50 ml) under nitrogen was dissolved endo-1S-1'-(((2-amino-7,7-dimethylbicyclo(2.2.1)-hept-1-yl)-methyl)-sulfonyl)-spiro(1H-indan-1,4'-piperidine)(50 mg, 0.000125 M) in methylene chloride (3 ml). Ethyl chloroformate (13.6 mg, 12 ml, 0.000125 M) was added via syringe. After two minutes, triethylamine (50 ml) was added to make the solution basic (pH=9). After 30 minutes, the reaction mixture was concentrated under reduced pressure (20 mm). The oil was chromatographed on a silica "flash" column with 40% ethyl acetate in hexane as eluent. Fractions 12-20 contained the product. These fractions were concentrated under reduced pressure (20 mm). Hexane-ether was added to the oil and removed under reduced pressure to yield 17 mg of the title compound as a white powder. NMR (CDCl₃) was consistent with structure.

HPLC 210-99.817% 254-100%

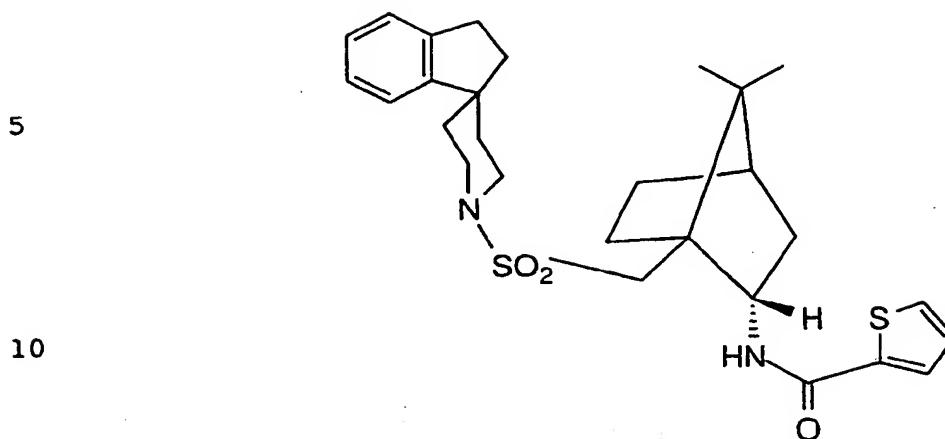
Mass Spectra: Calculated 474.668, Found 475.3

Analysis calculated for C₂₆H₃₈N₂O₄S

C, 65.79; H, 8.07; N, 5.90

Found: C, 66.05; H, 8.22; N, 5.72

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EXAMPLE 4

15 Endo-(1S)-1'-(((2-(2-thiophenecarbonylamino)-7,7-dimethylbicyclo(2.2.1)-hept-1-yl)-methyl)-sulfonyl)spiro(1H-indan-1,4'-piperidine)

20 In an oven-dried flask (50 ml) under nitrogen was dissolved endo-1S-1'-(((2-amino-7,7-dimethylbicyclo(2.2.1)-hept-1-yl)-methyl)-sulfonyl)-spiro(1H-indan-1,4'-piperidine)(50 mg, 0.000125 m) in methylene chloride (3 ml). The 2-thiophene carbonyl chloride (18 mg, 13.4 ml, 0.000125 m) was added via syringe. Triethylamine (50 ml) was added to make the mixture basic. The reaction mixture was concentrated to oil and chromatographed using a silica "flash" column with 40% ethyl acetate in hexane as eluent. Fractions 12-20 contained the product. Fractions 11-18 contained the desired product and these were concentrated to an oil. Ether-hexane was added and removed to

25 yield 27 mg of the title compound as a white amorphous powder.

HPLC 210-98.873% 254-97/931%

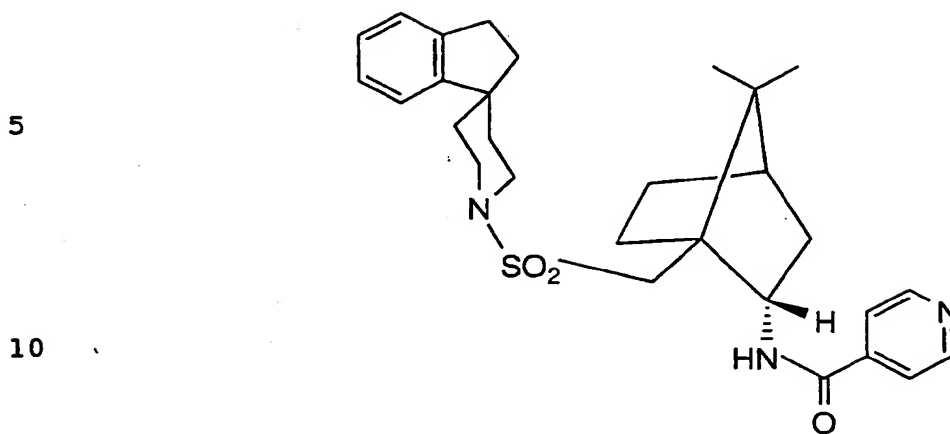
Mass Spectra: Calculated, 512.738; Found, 513.3

Analysis calculated for C₂₈H₃₆N₂O₃S₂ 0.72 hexane

30 C, 63.97; H, 7.11; N, 5.33

Found: C, 63.59; H, 6.78; N, 5.08

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EXAMPLE 5

15 Endo-(1S)-1'-(((2-(isonicotinylamino)-7,7-dimethyl-bicyclo(2.2.1)-hept-1-yl)-methyl)-sulfonyl)spiro(1H-indan-1,4-piperidine)

20 In an oven-dried flask (50 ml) under nitrogen was dissolved endo-1S-1'-(((2-amino-7,7-dimethylbicyclo(2.2.1.)-hept-1-yl)-methyl)-sulfonyl)-spiro(1H-indan-1,4'-piperidine)(50 mg, 0.000125 m) in methylene chloride (3 ml). The isonicotinoyl chloride dihydrochloride (22.38 mg, 0.000125 m) was added. After 2 minutes, triethylamine (50 ml) was added so the pH equaled 9. The solvent was removed under reduced pressure and the product was purified by a "flash" silica column using methylene chloride (9)-methanol (1) as solvents. The product was contained in fractions 6-10 which were concentrated. The oil was treated with hexane-ether which was removed under reduced pressure. This gave 18 mg of the title compound as a white foam.

25 NMR (CDCl₃) was consistent with structure.

HPLC 210-95.84% 254-98.04%

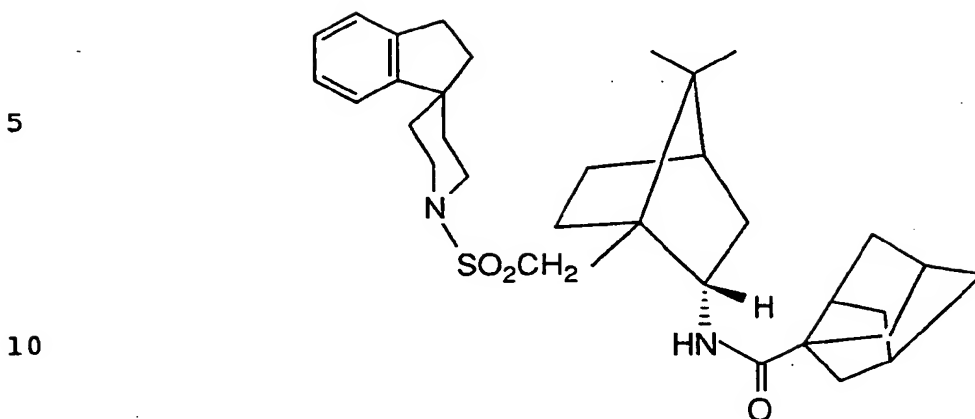
30 Mass Spectra: Calculated, 507.7; Found, 508.3

Analysis calculated for C₂₉H₃₇N₃O₃S

C, 68.61; H, 7.35; N, 8.28

Found: C, 68.46; H, 6.99; N, 7.90

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EXAMPLE 6

15 Endo-(1S)-1'-(((2-(noradamantyl-1-carboxylamino)-7,7-dimethylbicyclo(2.2.1)-hept-1-yl)-methyl)-sulfonyl)spiro(1H-indan-1,4'-piperidine)

Step 1: Noradamantyl-1-carboxyl chloride

To a solution of noradamantylcarboxylate (20.8 mg, 0.000125 M) in methylene chloride (4 ml) in a round bottom flask (50 ml) under an atmosphere of nitrogen at 0°C was added oxalyl chloride (120 ml) via syringe. Dimethylformamide (7 ml) was added and the solution was stirred at 0°C for 15 minutes. The reaction mixture was allowed to warm to room temperature and stir for 45 minutes. The solvent was removed under reduced pressure (20 mm). Twice additional methylene chloride was added and removed under reduced pressure. The acid chloride of the title compound was kept under high vacuum (0.05 mm) for one hour before using in the next step.

30 Step 2: Endo-(1S)-1'-(((2-(noradamantyl-1-carboxylamino)-7,7-dimethylbicyclo(2.2.1)-hept-1-yl)-methyl)sulfonyl)-spiro(1H-indan-1,4'-piperidine)

Adamantyl-1-carboxyl chloride was dissolved in methylene chloride (4 ml) and endo-1S-1'-(((2-amino-7,7-dimethylbicyclo(2.2.1)-hept-1-yl)-methyl)-sulfonyl)spiro(1H-indan-1,4'-piperidine) (50 mg, 0.000125 m) was added. After two minutes, triethylamine (100 ml) was

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introduced via syringe. The solvent was removed under reduced pressure and the oil was chromatographed on silica with 40% ethyl acetate in hexane as elutant. The product fractions were collected and concentrated to an oil, which became an amorphous white solid upon addition and removal of ether-hexane. This gave 10 mg of the title compound.

NMR (CDCl₃) was consistent with structure.

HPLC 210-98.427% 254-100%

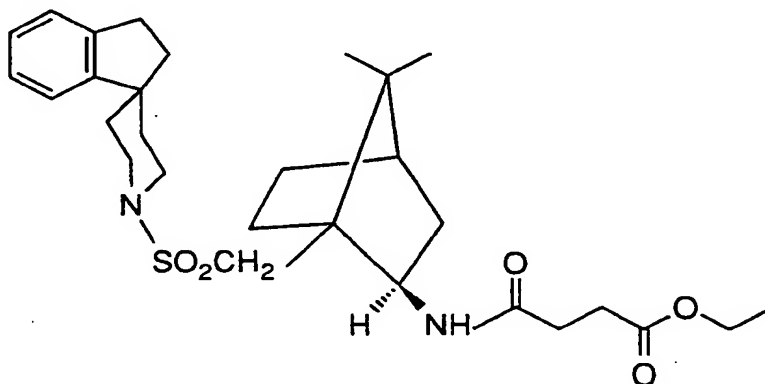
Mass Spectra: Calculated, m/e 550.81; Found, m/e 551.3

Analysis calculated for C₃₃H₄₆N₂O₃S

C, 71.96; H, 8.42; N, 5.09

Found: C, 71.57; H, 8.71; N, 4.77

EXAMPLE 7



Exo-(1S)-1'-(((2-(ethyl succinoylamino)-7,7-dimethylbicyclo(2.2.1)-hept-1-yl)-methyl)-sulfonyl)spiro(1H-indan-1,4'-piperidine)

To a solution of exo-(1S)-1'-(((2-(amino)-7,7-dimethylbicyclo(2.2.1)-hept-1-yl)methyl)-sulfonyl)spiro(1H-indan-1,4'-piperidine) (50 mg, 0.000125 M) in methylene chloride (3 ml) under a blanket of nitrogen was added ethyl succinoyl chloride (20.6 mg, 0.000125 M). After two minutes, triethylamine (50 ml) was added with a syringe. The pH of the solution was 9. After 15 minutes, a new spot was observed on the tlc (silica-40% ethyl acetate in hexane). The reaction mixture was concentrated and the oil was chromatographed on

- 74 -

a silica "flash" column with 40% ethyl acetate as solvent. Fractions 24-48 contained the product. These fractions were collected and concentrated. Ether-hexane was added and removed to yield 21.3 mg of the title compound as a white powder.

5

NMR (CDCl₃) was consistent with structure.

HPLC 210-99.190% 254-96.914%

Mass Spectra: Calculated m/e, 530.732; Found m/e, 531.5

Analysis calculated for C₂₉H₄₂N₂O₅S " 0.25 H₂O

10

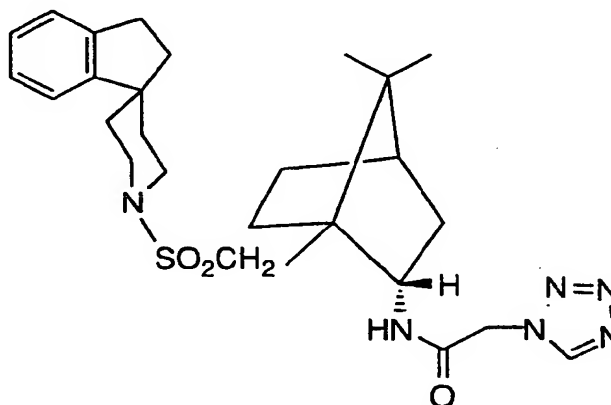
C, 65.08; H, 8.00; N, 5.23

Found: C, 65.16; H, 8.03; N, 5.09

EXAMPLE 8

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Endo-(1S)-1'-(((2-(tetrazole-1-acetylamino)-7,7-dimethylbicyclo-(2.2.1)-hept-1-yl)-methyl)-sulfonyl)-spiro(1H-indan-1,4-piperidine)

30

In an oven-dried flask (50 ml) under nitrogen was dissolved endo-1S-1'-(((2-amino-7,7-dimethylbicyclo(2.2.1)-hept-1-yl)-methyl)-sulfonyl)-spiro(1H-indan-1,4'-piperidine)(50 mg, 0.000125 M), tetrazole-1-acetic acid (16 mg, 0.000125 M), and benzotriazol-1-yloxytris(dimethylamino)phosphonium-hexafluorophosphate (Sequalog) (55 mg, 0.000125 M) in acetonitrile (3 ml). Diisopropylethylamine (50 ml) was added to make the solution basic. After tlc (silica-methylene chloride(9)-methanol(1)) showed a new spot, the reaction was concentrated to an oil. The oil was dissolved in methylene chloride-

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ether (1:3) and the solution was washed with water, sodium bicarbonate (sat., aqueous), water, 10% potassium bisulfate, and brine. After drying with sodium sulfate, the solution was filtered and concentrated to oil, which was chromatographed on a silica "flash" column with 10% methanol in methylene chloride. Fractions 5-10 contained the product and were collected and concentrated. Ether-hexane was added and removed to yield the title compound as a white powder.

NMR (CDCl₃) was consistent with structure.

HPLC: 210-98% 254-100%

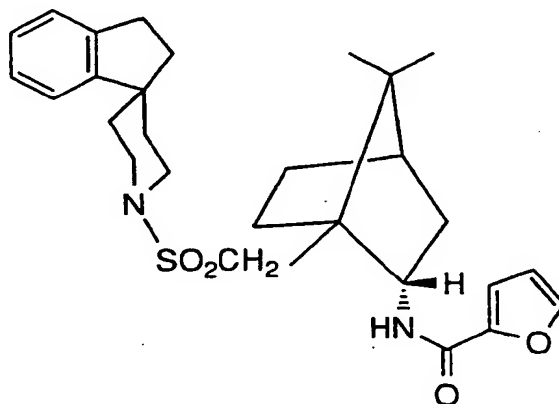
Mass Spectra: Calculated, 513.679; Found, 513.3

Analysis calculated for C₂₆H₃₆N₆O₃S " 0.25 H₂O

C, 60.37; H, 7.11; N, 16.25

Found: C, 60.28; H, 6.96; N, 16.18

EXAMPLE 9



Endo-(1S)-1'-(((2-(2-furoylamino)-7,7-dimethylbicyclo-(2.2.1)-hept-1-yl)-methyl)sulfonyl)spiro(1H-indan-1,4-piperidine)

In an oven-dried flask (50 ml) under nitrogen was dissolved endo-1S-1'-(((2-amino-7,7-dimethylbicyclo(2.2.1)-hept-1-yl)-methyl)-sulfonyl)-spiro(1H-indan-1,4'-piperidine)(50 mg, 0.000125 M) in methylene chloride (3 ml) and 2-furoyl chloride (16.3 mg, 0.000125 M) was added. After two minutes, triethylamine (150 ml) was added so the pH equaled 9. The solvent was removed under pressure and the

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product was purified by a silica "flash" column using 40% ethyl acetate in hexane as solvents. The product was contained in fractions 6-10 which were concentrated. The oil was treated with hexane-ether which was removed under reduced pressure.

5

NMR (CDCl₃) was consistent with structure.

HPLC: 210-99.341% 254-99.576%

Mass Spectra: Calculated, 496.674; Found, 497.3

Analysis calculated for C₂₈H₃₆N₂O₄S

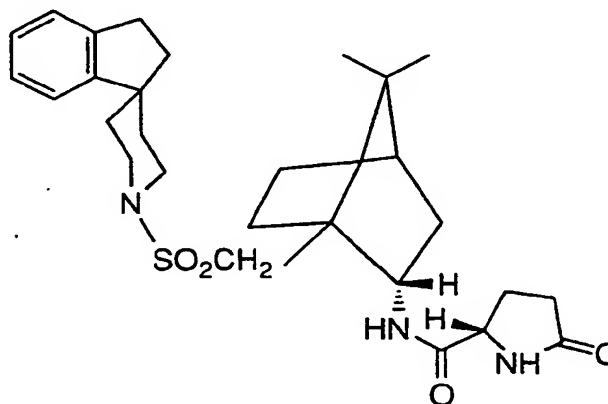
10 C, 67.71; H, 7.31; N, 5.64

Found: C, 67.41; H, 7.39; N, 5.46

EXAMPLE 10

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Endo-(1S)-1'-(((2-(S-(1)-2-oxo-pyrrolidin-5-yl-carbonyl)amino)-7,7-dimethylbicyclo(2.2.1)-hept-1-yl)-methyl)-sulfonyl)spiro(1H-indan-1,4-piperidine)

30

In an oven-dried flask (50 ml) under nitrogen was dissolved endo-1S-1'-(((2-amino-7,7-dimethylbicyclo(2.2.1)-hept-1-yl)-methyl)-sulfonyl)-spiro(1H-indan-1,4'-piperidine)(50 mg, 0.000125 M), S-(1)-2-oxo-pyrrolidine-5-carboxylic acid (16.1 mg, 0.000125 M), and benzotriazol-1-yloxytris(dimethyl-amino)phosphonium-hexafluorophosphate (Sequalog) (55 mg, 0.000125 M) in acetonitrile (3 ml). Diisopropyl-ethylamine (50 ml) was added to make the solution basic. After tlc(silica-methylene chloride(9)-methanol(1)) showed a new spot,

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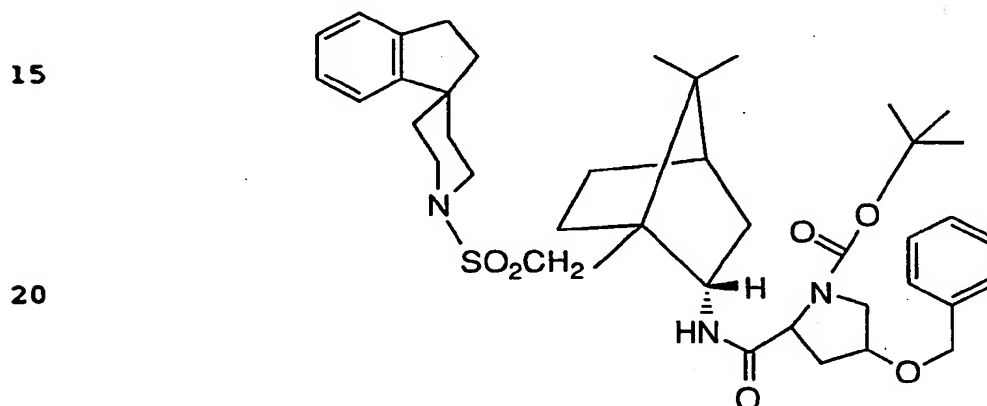
the reaction was concentrated to an oil. The oil was dissolved in methylene chloride-ether(1:3) and the solution was washed with water, sodium bicarbonate (sat., aqueous), water, 10% potassium bisulfate, and brine. After drying with sodium sulfate, the solution was filtered and concentrated to an oil. Ether-hexane was added and removed under reduced pressure to give the title compound as a white solid.

NMR (CDCl₃) was consistent with structure.

HPLC: 210-93.102% 254-92.292%

Mass Spectra: Calculated, 513.705; Found, 514.3

EXAMPLE 11



Endo-(1S)-1'-(((2-(L-N-(tert-butoxycarbonyl)-4-benzyl-oxy-prolinoylamino)-7,7-dimethylbicyclo(2.2.1)-hept-1-yl)-methyl-sulfonyl)spiro(1H-indan-1,4-piperidine)

In an oven-dried flask (50 ml) under nitrogen was dissolved endo-1S-1'-(((2-amino-7,7-dimethylbicyclo(2.2.1)-hept-1-yl)-methyl)-sulfonyl)spiro(1H-indan-1,4'-piperidine)(50 mg, 0.000125 M), L-N(tert-butoxycarbonyl)-4-benzyl-oxy-proline (40.2 mg, 0.000125 M), and benzotriazol-1-yloxytris(dimethylamino)phosphonium-hexafluorophosphate sequalog (55 mg, 0.000125 M) in acetonitrile (3 ml). Diisopropylethylamine (50 ml) was added to make the solution basic. After tlc(silica-methylene chloride(9)-methanol(1)) showed a new spot, the reaction was concentrated to an oil. The oil was dissolved

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in methylene chloride-ether(1:3) and the solution was washed with water, sodium bicarbonate (sat., aqueous), water, 10% potassium bisulfate, and brine. After drying with sodium sulfate, the solution was filtered and concentrated to an oil which was purified by "flash" silica chromatography with 40% ethyl acetate in hexane as solvent. Fractions 15-24 contained the product and they were collected and concentrated. Ether-hexane treatment provided a white solid which was the title compound. A 10 mg sample was used for characterization and testing with the remainder being used in subsequent steps.

NMR (CDCl₃) was consistent with structure.

HPLC: 210-99.003% 254-100%

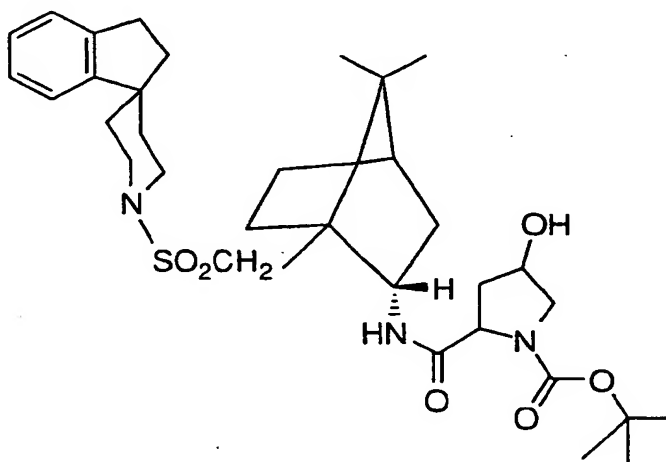
Mass Spectra: Cal'd, 705.965; Found, 706

Analysis calculated for C₄₀H₅₅N₃O₆S " 0.25 H₂O

C, 67.62; H, 7.87; N, 5.91

Found: C, 67.56; H, 8.11; N, 5.59

EXAMPLE 12



Endo-(1S)-1'-((((2-(L-N(tert.-butoxycarbonyl)-4-hydroxyprolinoylamino)-7,7-dimethylbicyclo(2.2.1)-hept-1-yl)methylsulfonyl)spiro(1H-indan-1,4-piperidine)

A mixture of Endo-(1S)-1'-((((2-(L-N(tert.-butoxycarbonyl)-4-benzyloxyprolinoylamino)-7,7-dimethylbicyclo(2.2.1)-

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hept-1-yl)-methyl)-sulfonyl)spiro(1H-indan-1,4-piperidine), ethanol (5 ml), and Pd(OH)₂ (60 mg) was hydrogenated on the Parr apparatus at 50 psi for 18 hours. The catalyst was removed by filtration and the solvent was removed under reduced pressure to yield the title compound as a white solid.

NMR (CDCl₃) was consistent with structure.

HPLC: 210-93.5% 254-(7.381%)

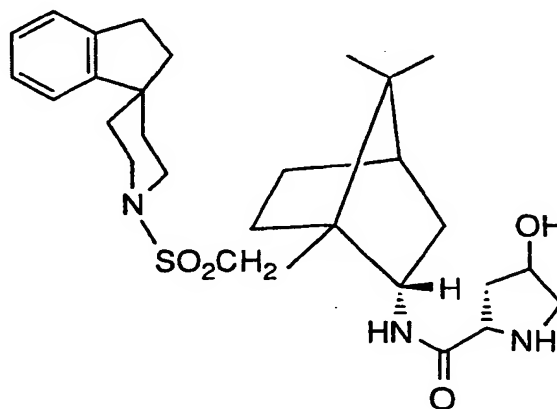
Mass Spectra: Calculated, 615.840; Found, 616

Analysis calculated for C₃₃H₄₉N₃O₆S " 1.5 H₂O

C, 61.65; H, 8.15; N, 6.53

Found: C, 61.46; H, 7.88; N, 6.90

EXAMPLE 13



Endo-(1S)-1'-((((2-(L-4-hydroxyprolinoylamino)-7,7-dimethylbicyclo(2.2.1)-hept-1-yl)-methyl)-sulfonyl)spiro(1H-indan-1,4-piperidine)hydrochloride

A mixture of Endo-(1S)-1'-((((2-(L-N(tert.-butoxy-carbonyl)-4-hydroxyprolinoylamino)-7,7-dimethylbicyclo(2.2.1)-hept-1-yl)-methyl)-sulfonyl)spiro(1H-indan-1,4-piperidine), was dissolved in ethyl acetate (5 ml) and cooled to -5°C. This was placed under a nitrogen atmosphere and hydrogen chloride gas was bubbled in for 10 minutes. The solvent was removed under reduced pressure. Ether was

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added and removed under reduced pressure to give 15.48 mg of the title compound as a white solid.

NMR (CDCl₃) was consistent with structure.

5 HPLC: 210-93.50% 254-93.812%

Mass Spectra: Calculated, 515.721 (free base); Found, 516.4

Analysis calculated for C₂₈H₄₁N₃O₄S HCl 0.25 H₂O

C, 60.41; H, 7.69; N, 7.54

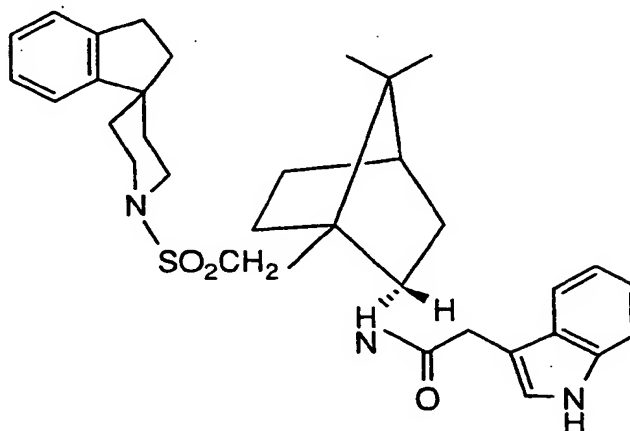
Found: C, 60.08; H, 7.73; N, 7.35

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EXAMPLE 14

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Endo-(1S)-1'-(((2-(3-indolylacetyl)amino)7,7-dimethyl-bicyclo-
(2.2.1)-hept-1-yl)methyl-sulfonyl)spiro(1H-indan-1,4-piperidine)

25

In an oven-dried flask (50 ml) under nitrogen was dissolved endo-1S-1'-(((2-amino-7,7-dimethylbicyclo(2.2.1.)-hept-1-yl)-methyl)-sulfonyl)spiro(1H-indan-1,4'-piperidine)(50 mg, 0.000125 M), 3-indolyl acetic acid (21.9 mg, 0.000125 M), and benzotriazol-1-yloxytris(dimethylamino)phosphonium-hexafluorophosphate (Sequalog) (55 mg, 0.000125 M) in acetonitrile (3 ml). Diisopropylethylamine (50 ml) was added to make the solution basic. After tlc(silica-methylene chloride(9)-methanol(1)) showed a new spot, the reaction was concentrated to an oil. The oil was dissolved in methylene chloride-ether (1:3) and the solution was washed with water, sodium bicarbonate (sat., aqueous), water, 10% potassium bisulfate, and brine. After

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drying with sodium sulfate, the solution was filtered and concentrated to an oil which was purified by "flash" silica chromatography with 10% methanol in methylene chloride as solvent. Fractions 12-19 contained the product and they were collected and concentrated. Ether-hexane treatment provided a white solid which was the title compound.

MR (CDCl₃) was consistent with structure.

HPLC: 210-99.829% 254-92.699%

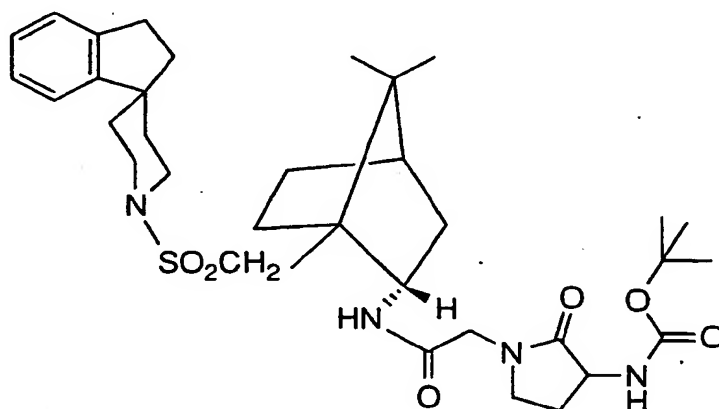
Mass Spectra: Calculated, 559.777; Found, 560.3

Analysis calculated for C₃₃H₄₁N₃O₃S " 0.5 H₂O

C, 69.69; H, 7.44; N, 7.51

Found: C, 69.70; H, 7.57; N, 7.20

EXAMPLE 15



Endo-(1S)-1'-((((2-(S-3-(tert.-butoxycarbonyl)amino)-2-oxo-1-pyrrolidineacetyl)amino)-7,7-dimethylbicyclo-(2.2.1)hept-1-yl)-methyl-sulfonyl)spiro(1H-indan-1,4'-piperidine)

In an oven-dried flask (50 ml) under nitrogen was dissolved endo-1S-1'-((((2-amino-7,7-dimethylbicyclo(2.2.1.)hept-1-yl)-methyl)-sulfonyl)spiro(1H-indan-1,4'-piperidine)(50 mg, 0.000125 M), S-3-((tert.-butoxycarbonyl)amino)-2-oxo-1-pyrrolidine acetic acid (32.2 mg, 0.000125 M), and benzotriazol-1-yloxytris (dimethylamino)-phosphoniumhexafluoro-phosphate (Sequalog) (55 mg, 0.000125 M) in acetonitrile (3 ml). Diisopropylethylamine (50 ml) was added to make

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the solution basic. After tlc(silica-methylene chloride(9)-methanol(1)) showed a new spot, the reaction was concentrated to an oil. The oil was dissolved in methylene chloride-ether(1:3) and the solution was washed with water, sodium bicarbonate (sat., aqueous), water, 10% potassium bisulfate, and brine. After drying with sodium sulfate, the solution was filtered and concentrated to an oil which was purified by "flash" silica chromatography with 10% methanol in methylene chloride as solvent. Fractions 15-28 contained the product and they were collected and concentrated. Ether-hexane treatment provided a white solid which was the title compound.

NMR (CDCl_3) was consistent with structure.

HPLC: 210-94.005% 254-96.33%

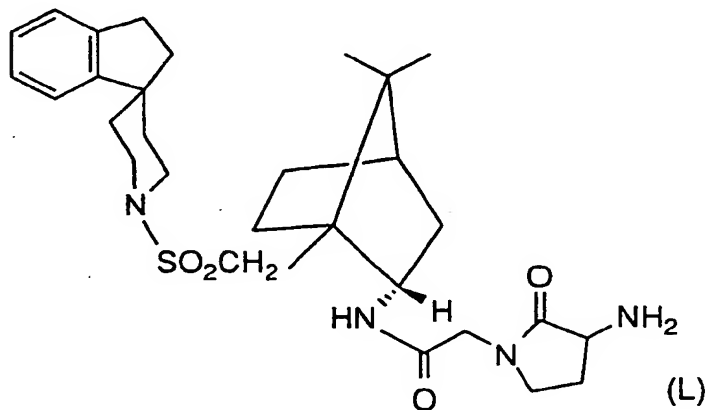
Mass Spectra: Calculated m/e, 642.859; Found m/e, 643.4

Analysis calculated for $\text{C}_{34}\text{H}_{50}\text{N}_4\text{O}_6\text{S}$ " 0.1 hexane

C, 63.79; H, 7.95; N, 8.59

Found: C, 63.66; H, 8.32; N, 8.29

EXAMPLE 16



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Endo-(1S)-1'-(((2-(S-3-amino)-2-oxo-1-pyrrolidine-acetyl-amino)-7,7-dimethylbicyclo(2.2.1)-hept-1-yl)-methyl)-sulfonyl)spiro(1H-indan-1,4-piperidine)hydrochloride

Endo-1S-1'-(((2-(S-3-(tert.-butoxycarbonyl)amino)-2-oxo-1-pyrrolidineacetyl-amino)-7,7-dimethyl-bicyclo(2.2.1.)hept-1-yl)-methyl)-sulfonyl)spiro(1H-indan-1,4'-piperidine) was dissolved in ethyl acetate (5 ml) and cooled to -5°C. This was placed under a nitrogen atmosphere and hydrogen chloride gas was bubbled in for 10 minutes. The solvent was removed under reduced pressure. Ether was added and removed under reduced pressure to give 23.7 mg of the title compound as a white solid.

NMR (CDCl₃) was consistent with structure.

HPLC: 210-96.562% 254-95.493%

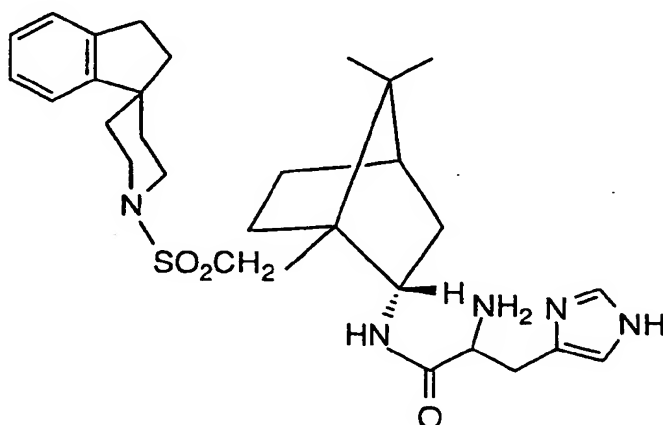
Mass Spectra: Calculated for free base m/e, 542; Found m/e, 543.3

Analysis calculated for C₂₉H₄₂N₄O₄S " H₂O " HCl

C, 58.32; H, 7.59; N, 9.38

Found: C, 58.14; H, 7.97; N, 9.21

EXAMPLE 17



Step 1: Endo-(1S)-1'-(((2-(L-N-tert-butoxycarbonyl-histidinoyl-amino)-7,7-dimethylbicyclo(2.2.1)-hept-1-yl)-methyl-sulfonyl)spiro(1H-indan-1,4-piperidine)

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In an oven dried flask (50 ml) under nitrogen were dissolved endo-1S-1'-(((2-amino-7,7-dimethylbicyclo(2.2.1.)hept-1-yl)-methyl)-sulfonyl)spiro(1H-indan-1,4'-piperidine) (50 mg, 0.000125 M), L-N-tert, butoxycarbonyl histidine (29.9 mg, 0.000125 M), and benzotriazol-1-yloxytris(dimethylamino)phosphonium-hexafluorophosphate (Sequalog) (55 mg, 0.000125 M) in acetonitrile (3 ml). Diisopropylethylamine (50 ml) was added to make the solution basic. After tlc(silica-methylene chloride(9)-methanol(1)) showed a new spot, the reaction was concentrated to an oil. The oil was dissolved in methylene chloride-ether (1:3) and the solution was washed with water, sodium bicarbonate (sat., aqueous), water, 10% potassium bisulfate, and brine. After drying with sodium sulfate, the solution was filtered and concentrated to an oil, which was purified by "flash" silica chromatography with 10% methanol in methylene chloride as solvent. Fractions 15-28 contained the product and they were collected and concentrated. Ether-hexane treatment provided a white solid which as the title compound.

NMR (CD₃OD) was consistent with structure.

HPLC: 210-97.822% 254-100%

Mass Spectra: Calculated m/e, 639.859; Found m/e, 640.3

Step 2: Endo-(1S)-1'-(((2-(L-N-histidinoylamino)-7,7-dimethylbicyclo(2.2.1)-hept-1-yl)-methyl-sulfonyl)spiro(1H-indan-1,4-piperidine)

Endo-1S-1'-(((2-(L-N-tert.butoxycarbonyl-histidinoylamino)-7,7-dimethylbicyclo(2.2.1.)-hept-1-yl)-methyl)-sulfonyl)-spiro(1H-indan-1,4'-piperidine) (50 mg, 0.000125 M) was dissolved in ethyl acetate (5 ml) and cooled to -5°C. This was placed under a nitrogen atmosphere and hydrogen chloride gas was bubbled in for 10 minutes. The solvent was removed under reduced pressure. Ether was added and removed under reduced pressure to give 27.5 mg of the title compound as a white solid.

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NMR (CD₃OD) was consistent with structure.

HPLC: 210-98.652% 254-100%

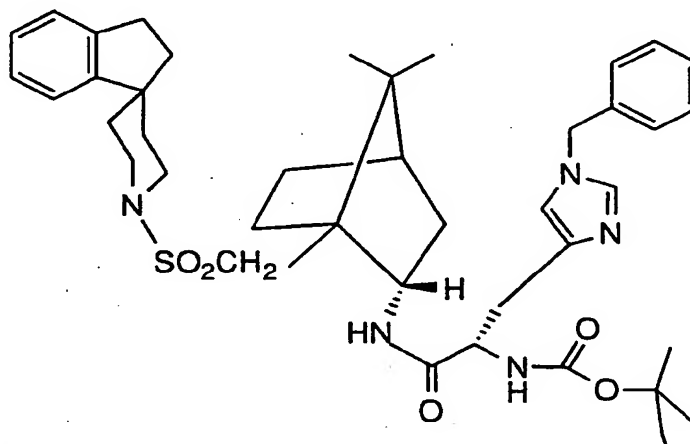
Mass Spectra: Calculated for free base m/e, 539.7; Found m/e, 540.3

Analysis calculated for C₂₉H₄₁N₅O₃S 2HCl 2H₂O

C, 53.69; H, 7.30; N, 10.79

Found: C, 53.58; H, 7.45; N, 11.00

EXAMPLE 18



Endo-(1S)-1'-(((2-(D-N-(tert.butoxycarbonyl)-im-benzylhistidino-ylamino)-7,7-dimethylbicyclo(2.2.1)-hept-1-yl)-methyl)sulfonyl)-spiro(1H-indan-1,4'-piperidine)

In an oven-dried flask (50 ml) under nitrogen were dissolved endo-1S-1'-(((2-amino-7,7-dimethylbicyclo(2.2.1)-hept-1-yl)-methyl)-sulfonyl)spiro(1H-indan-1,4'-piperidine) (50 mg, 0.000125 M), D-N-tert. butoxycarbonylim-benzyl-histidine (43 mg, 0.000125 M), and benzotriazol-1-yloxytris(dimethylamino)phosphoniumhexafluorophosphate (Sequalog) (55 mg, 0.000125 M) in acetonitrile (3 ml). Diisopropyl-ethylamine (50 ml) was added to make the solution basic. After tlc(silica-methylene chloride(9)-methanol(1)) showed a new spot, the reaction was concentrated to an oil. The oil was dissolved in methylene chloride-ether (1:3) and the solution was washed with water, sodium bicarbonate (sat., aqueous), water, 10% potassium bisulfate, and brine. After drying with sodium sulfate, the solution was filtered and

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concentrated. Ether-hexane provided a white solid which was the title compound.

NMR (CDCl₃) was consistent with structure.

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HPLC: 210-99.551%

Mass Spectra: Calculated, m/e 730.062; Found, m/e 730.6

Analysis calculated for C₄₁H₅₅N₅O₅S: 0.65 H₂O 0.4 hexane

C, 67.15; H, 8.04; N, 9.02

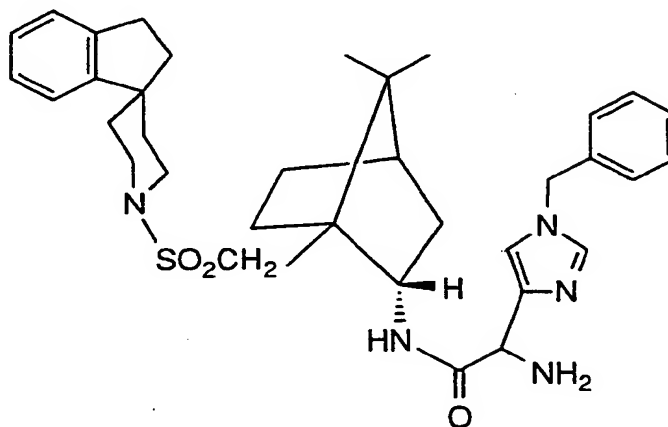
Found: C, 67.18; H, 7.73; N, 9.02

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EXAMPLE 19

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Endo-(1S)-1'-((((2-(D-im-benzylhistidinoylamino)-7,7-dimethylbicyclo-(2.2.1)-hept-1-yl)-methyl)-sulfonyl)spiro(1H-indan-1,4'-piperidine))-hydrochloride

30

Endo-(1S)-1'-((((2-(D-N-(tert.butoxycarbonyl)-im-benzylhistidinoylamino)-7,7-dimethylbicyclo(2.2.1.)-hept-1-yl)-methyl)-sulfonyl)spiro(1H-indan-1,4'-piperidine) was dissolved in ethyl acetate (5 ml) and cooled to -5°C. This was placed under a nitrogen atmosphere and hydrogen chloride gas was bubbled in for 10 minutes. The solvent was removed under reduced pressure. Ether was added and removed under reduced pressure to give the title compound as a white solid.

NMR (CDCl₃) was consistent with structure.

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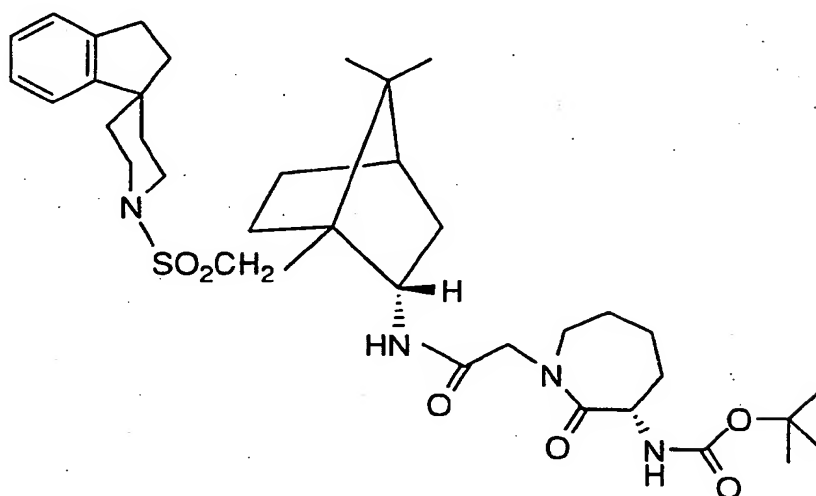
HPLC: 210-100%

Mass Spectra: Calculated m/e, 629.879; Found m/e, 630

Analysis calculated for $C_{36}H_{47}N_5O_3S \cdot HCl \cdot 0.1$ ethyl acetate 1.4 H_2O

C, 59.33; H, 7.20; N, 9.51

Found: C, 59.36; H, 7.03; N, 9.50

EXAMPLE 20

Endo-(1S)-1'-(((2-(S-3-tert.butoxycarbonylamino-2-oxo-1-azepineacetyl)amino)-7,7-dimethylbicyclo(2.2.1)-hept-1-yl)-methyl-sulfonyl)spiro(1H-indan-1,4-piperidine)

In an oven-dried flask (50 ml) under nitrogen was dissolved endo-1S-1'-(((2-amino-7,7-dimethylbicyclo(2.2.1)-hept-1-yl)-methyl)-sulfonyl)spiro(1H-indan-1,4'-piperidine)(50 mg, 0.000125 M), S-3-tert.butoxycarbonylamino-2-oxo-1-azepine acetic acid (32.8 mg), and benzotriazol-1-yloxytris (dimethylamino)phosphonium-hexafluorophosphate sequalog (55 mg, 0.000125 M) in acetonitrile (3 ml). Diisopropylethylamine (50 ml) was added to make the solution basic. After tlc(silica-methylene chloride(9)-methanol(1)) showed a new spot, the reaction was concentrated to an oil. The oil was dissolved in methylene chloride-ether(1.3) and the solution was washed with water, sodium bicarbonate (sat., aqueous), water, 10% potassium bisulfate, and

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brine. After drying with sodium sulfate, the solution was filtered and concentrated to an oil, which was purified by "flash" silica chromatography with 10% methanol in methylene chloride as solvent. The fractions which contained the product were collected and concentrated. Ether-hexane treatment provided a white solid which was the title compound. A 10 mg sample was saved for characterization and testing.

NMR (CDCl₃) was consistent with structure.

HPLC 210-100%

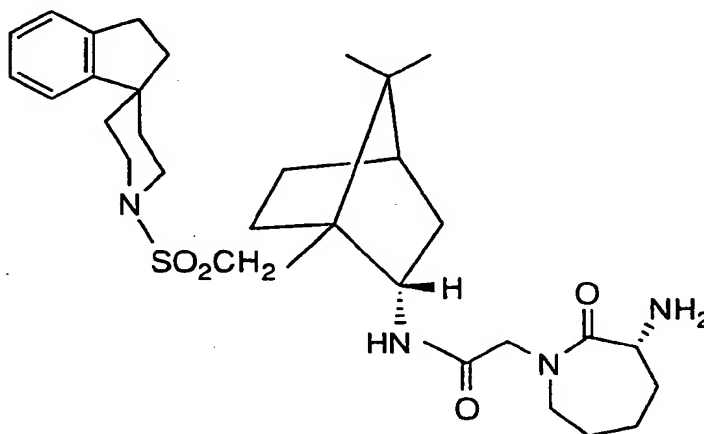
Mass Spectra calculated m/e 670.918 found m/e 671

Analysis calculated for C₃₆H₅₄N₄O₆S

C, 64.44; H, 8.11; N, 8.35

Found: C, 64.12; H, 8.23; N, 8.03

EXAMPLE 21



Endo-(1S)-1'-(((2-(S-3-amino-2-oxo-1-azepine acetyl-amino)-7,7-dimethylbicyclo(2.2.1)-hept-1-yl-methyl)-sulfonyl)spiro(1H-indan-1,4'-piperidine) hydrochloride

Endo(1S)-1'-(((2-(S-3-tert-butoxycarbonyl-amino-2-oxo-1-azepine acetyl-amino)-7,7-dimethylbicyclo(2.2.1)-hept-1-yl)-methyl)-sulfonyl)spiro(1H-indan-1,4'-piperidine) was dissolved in ethyl acetate (5 ml) and cooled to 5°C. This was placed under a nitrogen atmosphere and hydrogen chloride gas was bubbled in for 10 minutes. The solvent

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was removed under reduced pressure. Ether was added and removed under reduced pressure to give the title compound as a white solid.

NMR(CDCl_3) was consistent with structure.

5 HPLC 210-100%

Mass Spectra: Calculated m/e, 570.802; Found m/e, 571

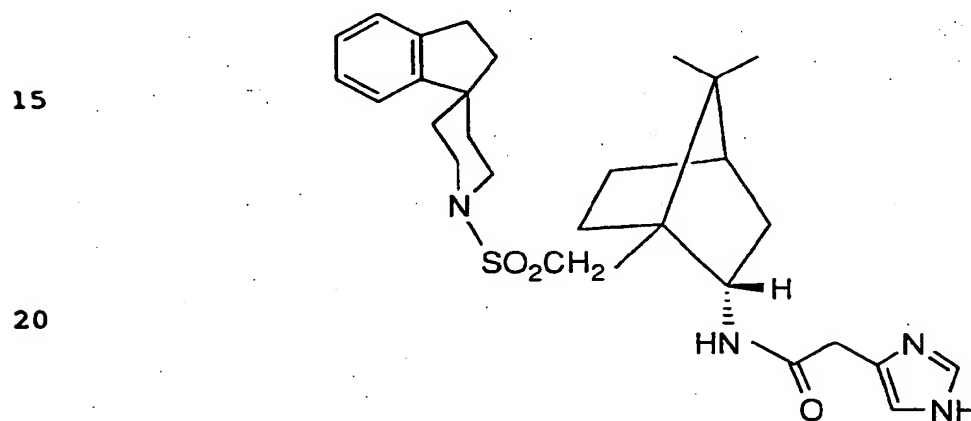
Analysis calculated for $\text{C}_{31}\text{H}_{46}\text{N}_4\text{O}_4\text{S} \cdot \text{HCl} \cdot 1.10$

$\text{H}_2\text{O} \cdot 0.40$ ethyl acetate

C, 59.11; H, 7.97; N, 8.46

10 Found: C, 59.09; H, 8.00; N, 8.45

EXAMPLE 22



25 Endo-(1S)-1'-(((2-(4-imidazoleacetyl amino)-7,7-dimethylbicyclo-(2.2.1)-hept-1-yl)-methyl)-sulfonyl)spiro(1H-indane-1,4'-piperidine)-hydrochloride

N,N-bis(2-chloroethyl)-t-butylcarbamate

30 Di-t-butyl dicarbonate (62 g, 0.28 mole, available from Aldrich) and bis(2-chloroethyl)amine hydrochloride (55 g, 0.21 mole, available from Aldrich) were stirred together in methylene chloride (400 mL). Triethylamine (42 mL, 0.3 mole) was added dropwise but briskly to the stirred suspension. After 10 minutes, additional triethylamine (ca. 5-6 mL) was added to adjust the pH of the mixture (as determined by spotting a sample on E. Merck pH 5-10 colorpHast sticks,

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moistened with water) to 9-9.5. The mixture was stirred for 1 hour at ambient temperature, then filtered. The filtrate was divided in half, and each half (ca. 300 mL) was flash chromatographed on a separate 15", 2" diameter silica column packed with 3:2 (v:v) methylene chloride:hexane and eluted with 9:1 methylene chloride:hexane. 100 mL fractions were taken, and the product was obtained in fractions ca. 6-12. Assay was by TLC on silica gel plates, eluted with methylene chloride and visualized with phosphomolybdic acid stain (R_f ca. 0.75). Evaporation of the combined product fractions from both columns in vacuo provided the title compound (70 g) as a colorless oil. The oil was twice dissolved in dry THF and evaporated in vacuo to remove methylene chloride.

1'-(t-Butyloxycarbonyl)spiro(1H-indene-1,4'-piperidine)

To a solution of indene (36.2 g, 310 mmole) in dry tetrahydrofuran (THF, 40 mL) cooled in an ice bath and maintained under a nitrogen blanket was added (dropped funnel) lithium bis(trimethylsilyl)-amide (620 mL of a 1.0 M solution in THF; 620 mmole, available from Aldrich) over 30 minutes. The mixture was stirred in the cold for 30 minutes, then transferred by cannula over 20 minutes to a solution of N,N-bis(2-chloroethyl)-t-butylcarbamate (70 g, 290 mmole) in THF (40 mL), stirred in an ice bath. The mixture was stirred for 2 hours in the cold and for 30 minutes at ambient temperature under nitrogen, then evaporated in vacuo to a foam. CH₂Cl₂ (400 mL) was added and the resulting mixture divided in half. Each half was poured onto a silica gel column (15", 2" id) packed and eluted with 1:1 hexane:CH₂Cl₂ (2 L) followed by 1:4 hexane: CH₂Cl₂. The product fractions (fractions 3-9 of 200 mL fractions) were evaporated to dryness in vacuo to provide 1'-(t-butyloxycarbonyl)spiro (indene-1,4'-piperidine), 90 g total, as a crude yellow solid. The solid was taken up in boiling hexane (400 mL), cooled, and the crystallized solid filtered. The filtrate was repeatedly boiled down to 1/2 its volume, cooled and filtered to obtain successive crops, providing a total

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of 54 g of pure product. The residue was rechromatographed to provide another 6.7 g (60.7 g total).

Spiro(1H-indene-1,4'-piperidine) hydrochloride

5 1'-(t-Butyloxycarbonyl)spiro(indene-1,4'-piperidine) (60.7 g) in ethyl acetate (700 mL) was stirred in an ice bath and saturated with HCl (g) for 30 minutes, keeping the internal temperature $\leq 12^{\circ}\text{C}$. The mixture was stirred in the cold an additional 30 minutes, then evaporated to dryness. Ethyl acetate was added and removed in vacuo 10 three times, and the residue was triturated with diethyl ether and filtered to provide spiro(1H-indene-1,4'-piperidine) hydrochloride.

(1S)-1'-(((7,7-dimethyl-2-oxobicyclo(2.2.1)hept-1-)methyl)-sulfonyl)-spiro(1H-indene-1,4'-piperidine)

15 Spiro(1H-indene-1,4'-piperidine) hydrochloride (45.4 g, 0.2 mole) and (+)-10-camphorsulfonyl chloride (62.5 g, 0.25 mole, available from Aldrich) were combined in CH_2Cl_2 (700 mL) and treated with triethylamine (68.5 mL, 0.5 mole). Additional triethylamine was added as needed to adjust the pH of the mixture to 9- 20 9.5 (moistened E. Merck colorpHast sticks). The mixture was stirred at ambient temperature for 1 hour, then poured onto a silica gel column (10", 2" id) packed with CH_2Cl_2 and eluted with 1:1 $\text{Et}_2\text{O}:\text{CH}_2\text{Cl}_2$. The product fractions were combined and evaporated to dryness in vacuo 25 to provide the title compound as a solid which was recrystallized from petroleum ether and dried 6 hours in vacuo at ambient temperature: (m.p. $146-147^{\circ}\text{C}$).

TLC: $R_f=0.44$ silica gel (CH_2Cl_2).

NMR: Consistent with structure.

30 HPLC: $>99.7\%$ pure.

MS: Molecular ion at m/e - 399

Analysis calculated for $\text{C}_{23}\text{H}_{29}\text{NO}_3\text{S}$

C, 69.14; H, 7.32; N, 3.51

Found: C, 68.97; H, 7.2; N, 3.38

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(1S)-1'-(((7,7-dimethyl-2-oximinobicyclo(2.2.1)hept-1-yl)-methyl)-sulfonyl)spiro(1H-indene-1,4'-piperidine)

(1S)-1'-(((7,7-dimethyl-2-oxobicyclo(2.2.1)hept-1-yl)methyl)sulfonyl)spiro(1H-indene-1,4'-piperidine) (30 g, 0.075 mole) in pyridine (500 mL) was heated in an oil bath to 70°C (internal). Hydroxylamine hydrochloride (30 g) was added in three portions over ca. 20 minutes. After 2 hours, an additional 10 g of hydroxylamine hydrochloride was added (over 10 minutes). At 30, 40 and 50 minutes additional elapsed time, further 3 g lots of hydroxylamine hydrochloride were added. After another 30 minutes, the mixture was poured into water (2 L) and extracted 3X with ethyl acetate (300 mL portions). The organic layers were combined, washed with 1N HCl (600 mL total), dried over sodium sulfate, filtered, and evaporated to dryness in vacuo. EtOH (abs; ca. 250 mL) was added to the resulting thick syrup and the solution allowed to stand at ambient temperature overnight. The mixture was filtered and the filtrate boiled down to ca. 80 mL. After standing, the mixture was again filtered and boiled down to ca. 20 mL. After a third filtration, the filtered solids were combined to give the title compound (28 g).

Endo-(1S)-1'-(((2-amino-7,7-dimethylbicyclo(2.2.1)hept-1-yl)-methyl)sulfonyl)spiro(1H-indane-1,4'-piperidine)

Freshly prepared, activated Raney Nickel catalyst (ca. 30 g) in water was allowed to settle and the water decanted. Abs. ethanol (300 mL) was added, and the mixture swirled and again allowed to settle. The solvent was decanted. Two more wash-decant cycles with 150 mL of ethanol were similarly carried out. (1S)-1'-(((7,7-dimethyl-2-oximinobicyclo(2.2.1)hept-1-yl)methyl)sulfonyl)-spiro(1H-indene-1,4'-piperidine) (30 g) was stirred in a mixture of abs. ethanol (450 mL) and 2-methoxyethanol (900 mL), nitrogen was bubbled through the suspension/solution, and the Raney Nickel catalyst was added. The mixture was hydrogenated under 50 psi overnight. TLC (9:1 CH₂Cl₂:MeOH, silica gel) showed the reaction to be complete. The catalyst was removed by filtration, and the filtrate evaporated to dryness in vacuo.

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The crude solid (27 g) was divided into 7 g batches, and each batch was dissolved in methylene chloride (ca. 200 mL) and flash chromatographed on silica (700 g in a 100 mm column, packed and eluted with 8% (v/v) methanol in methylene chloride), taking 200 mL fractions.

5 The exo isomer of the title amine was obtained in fractions ca. 5-7, and the desired endo isomer in fractions ca. 8-16. TLC was on silica, eluted with 8% methanol/methylene chloride, phosphomolybdic acid stain. The combined product fractions were evaporated to dryness to provide the title compound (4.5 g from each 7 g lot, ca 18 g total) as a colorless

10 solid.

Endo-(1S)-1'(((2-(4-imidazoleacetyl amino)-7,7-dimethylbicyclo-(2.2.1)-hept-1-yl)methyl)sulfonyl)spiro(1H-indane-1,4'-piperidine

15 hydrochloride

4.56 g (11.3 mmols) of Endo-(1S)-1'(((2-amino-7,7-dimethylbicyclo-(2.2.1)hept-1-yl)methyl)sulfonyl)spiro(1H-indane-1,4'-piperidine) was dissolved in 50 mL DMF and the solution treated with 2.30 g (14.1 mmols) of 4-imidazole acetic acid, 1.9 g (14.1 mmols) of 1-hydroxybenzotriazole hydrate (HBT), and 2.7 g (14.1 mmols) of 1-ethyl-3-(3-dimethylaminopropyl) carbodiimide HCl (EDC). The

20 pH of the suspension was adjusted to 9.5 with 4.65 mL (33.4 mmols) of triethylamine and the reaction mixture stirred at 25°C for 18 hours.

DMF was removed in vacuo and the crude purplish residue treated with water and extracted with EtOAc (3X). The organics were combined, washed with H₂O (1X), brine (1X), dried over Na₂SO₄, filtered and stripped to dryness in vacuo. Flash chromatography of the crude product on silica gel (114/10/1 of CH₂Cl₂/MeOH/conc. NH₄OH) gave 5.29 g (92%) of desired product as a white foam.

25

5.17 g (10.1 mmols) of this product was dissolved in 100 mL EtOAc. While stirring vigorously, a solution of HCl (g) in EtOAc was added dropwise until precipitation ceased. The slightly gummy mixture was stirred 15 minutes at 25°C, then evaporated to dryness in vacuo. The residue was restripped 3X from EtOAc, then 3X from

30

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Et₂O. The white solid was scraped from the walls of the flask, triturated with Et₂O and 5.3 g of hydrochloride salt collected.

M.P.: 93-167°C (slow foam)

5 HPLC: 99.4%

PMR: Consistent with structure, plus 0.30 ethyl acetate, 0.05 ether and H₂O.

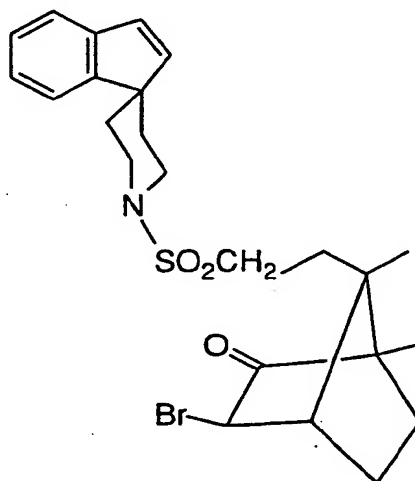
M.S.: M+H + 511 (FAB)

10 Analysis calculated for C₂₈H₃₈N₄O₃S " HCl " 0.30 C₄H₈O₂ " 0.05 C₄H₁₀O " 0.4 H₂O. (M.W. 584.48)

C, 60.41; H, 7.36; N, 9.59

Found: C, 60.38; H, 7.46; N, 9.33

EXAMPLE 23



1-[[6-bromo-1,7-dimethyl-2-oxobicyclo[2.2.1]hept-7-yl)methyl]-sulfonyl]-spiro[1H-indene-1,4'-piperidine]

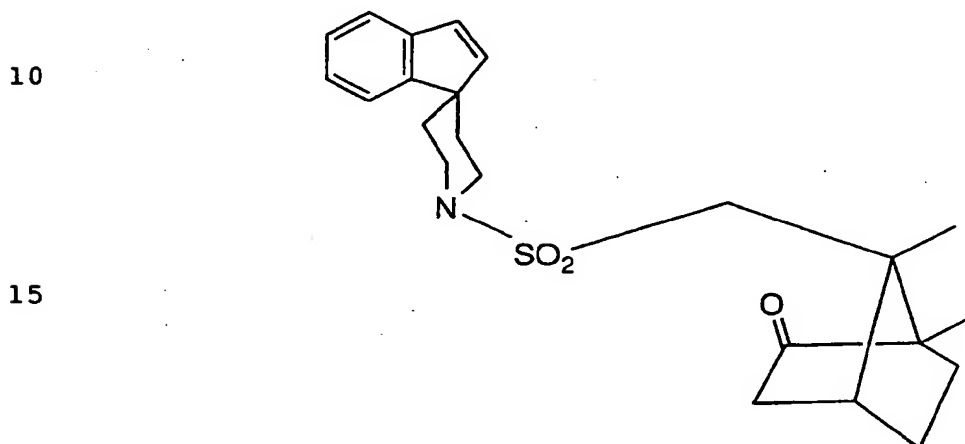
30 Dissolved 100 mg of (+)-3-Bromocamphor-sulfonic acid ammonium salt (.304 mM) in 15 mL of DLM. Added 5 eq of SOCl₂ (FW=118.97; d=1.631; 1.52 mM; 120 mL). The mixture was allowed to react overnight, then concentrated to obtain 92.7 mg of the crude sulfonyl chloride. The 92.7 mg of sulfonyl chloride was dissolved in 25 mL of dry THF. To this was added 1.1 eq of indene salt (68.59 mg)

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and 2 eq of TFA, which was allowed to react at room temperature for three hours. The product was concentrated and washed with HCl, H₂O and brine. Flash chromatography in 20% EtOAc/petroleum ether.

5 HPLC 97.7% at 13.52 min.

EXAMPLE 24



20 (1R-syn)-1'-[[[(1,7-dimethyl-2-oxobicyclo[2.2.1]hept-7-yl)methyl)-sulfonyl]-spiro[1H-indene-1,4'-piperidine]

To a solution of the product of Example 23 (107 mg, 0.300 mmol) in glacial acetic acid (10 mL) was added zinc dust (24 mg, 0.367 mmol). The temperature was then increased to reflux. After 30 minutes, the mixture was cooled to room temperature, filtered, then concentrated under reduced pressure. Purification by flash chromatography (35% ethyl acetate in petroleum ether as eluent) afforded 80 mg of the product as a white amorphous foam.

30 NMR (300 MHz, CDCl₃): Consistent with structure.

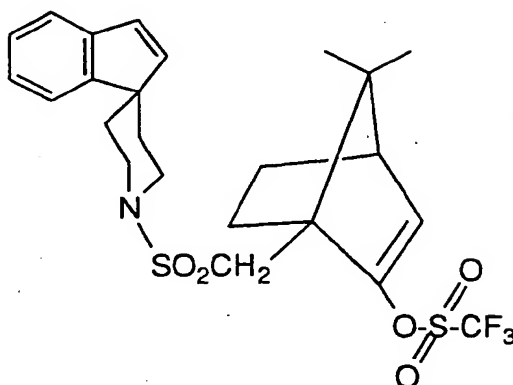
HPLC (Vydac C18 column, gradient from 95/5 to 0/100 H₂O/CH₃CN with 0.1% TFA, 15 min. gradient, flow rate = 1.5 mL/min): purity = 98%, r.t. = 12.67 min.

FABMS: [M+1]⁺ at 400.91

Analysis calculated for C₂₃H₂₉NO₃S

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Found: C, 69.13; H, 7.32; N, 3.51
C, 69.25; H, 7.30; N, 3.48

EXAMPLE 25

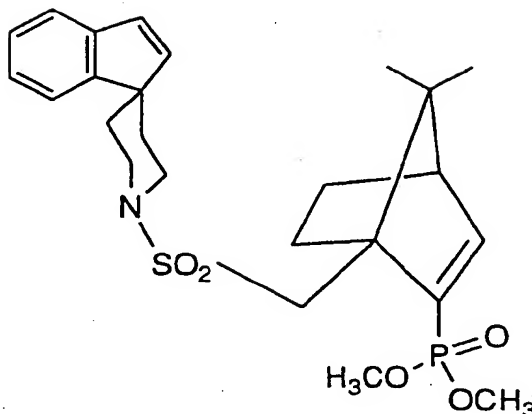
- 15 (1S)-1'(((2-(trifluoromethyl)sulfonyl)oxy)2,3-ene-7,7-dimethylbicyclo(2.2.1)hept-1-yl)methyl)sulfonyl)-spiro(1H-indene-1,4'-piperidine)

To a solution of (1S)-1'(((7,7-dimethyl-2-bicyclo(2.2.1)hept-1-yl)methyl)sulfonyl)spiro(1H-indene-1,4'-piperidine) (2g, 5.0 mmol) and 2,6-di-tert-butyl-4-methylpyridine (1.5 g, 7.5 mmol) in CH₂Cl₂ (25 ml) was added triflic anhydride (1.3 ml, 7.5 mmol) and the mixture was stirred at room temperature for 30 minutes. The mixture was then diluted with CH₂Cl₂ (30 ml) and filtered. The filtrate was then washed with 5% HCl (2x50 ml), saturated NaHCO₃ (2x50 ml), and brine, dried over Na₂SO₄, and evaporated.

The crude triflate was purified by flash chromatography eluting with 20% ethylacetate in hexanes to yield 1.7 g of the title product as a white foam (64%).

- 30 HPLC RT = 12.75 min.
NMR (CDCl₃) in agreement with title compound.
FAB MS: 532 (M+1)
Analysis calculated for C₄₂H₂₈NS₂O₅F₃
N, 2.63, C, 54.22, H, 2.63
Found: N, 2.37; C, 54.42; H, 5.34

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EXAMPLE 26

15 (1S)-1'-(((2-(dimethylphosphonyl)oxy)2,3-ene-7,7-dimethyl-
bicyclo(2.2.1)hept-1-yl)sulfonyl)spiro(1H-indene-1,4'-piperidine)

A mixture of the triflate product of Example 25 (50 mg, 0.097 mmol), dimethyl phosphite (13 ml, 0.14 mmol), triethylamine (61 ml, 0.44 mmol), and tetrakis(triphenylphosphine)palladium (5 mg, 0.005 mmol) in DMF (3 ml) was stirred under an atmosphere of argon for 1 hour. The reaction was then diluted with CHCl₃ (25 ml). The chloroform was washed with 5% HCl (2x25 ml) and brine, dried over Na₂SO₄ and evaporated to dryness. Purification via flash chromatography (25% ethylacetate in hexanes) afforded 40 mg of the title compound as a white solid (86%).

25

HPLC RT = 10.31 min.

NMR(CDCl₃) in agreement with title compound

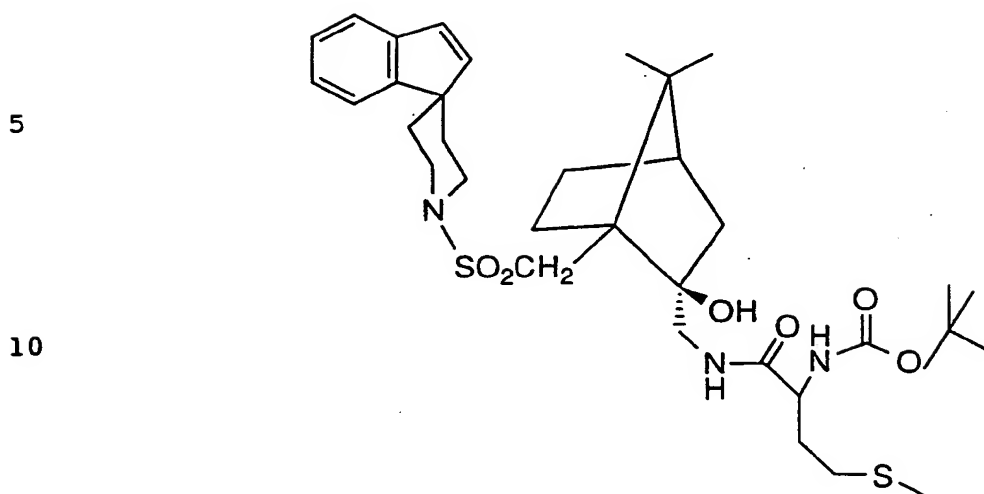
FAB MS: 492 (M+1)

Analysis calculated for C₂₅H₃₄NSO₅P 0.5 H₂O

30 N, 2.80; C, 59.99; H, 7.05

Found: N, 2.71; C, 59.90; H, 7.49

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EXAMPLE 27

15 [1-[[[exo-2-hydroxy-7,7-dimethyl-1-[spiro[1H-indene-1,4-piperidin]-1-yl-sulphonyl)methyl]bicyclo[2.2.1]hept-2-yl)methyl]amino]carbonyl]-3-(methylthio)propyl]-carbamic acid-1,1-dimethylethyl ester

To a stirred solution of (1S)-1'-(((exo-2-hydroxy-endo-2-aminomethyl-7,7-dimethylbicyclo(2.2.1)hept-1-yl)methyl)sulfonyl)-
 20 spiro(1H-indene-1,4'-piperidine) (600 mg, 1.39 mmole) in 5 ml of dry, degassed N,N-dimethylformamide was added Boc-L-methionine (381 mg, 1.53 mmole) and 743 mg (1.68 mmole) of benzotriazol-1-yloxy tris(dimethylamino)phosphonium hexafluorophosphate (BOP) at room temperature. The resulting reaction mixture was protected from
 25 moisture and the pH was adjusted to 8-9 with diisopropylethylamine. After one hour, all volatile components were removed under reduced pressure and the residue was dissolved in 250 ml of ethyl acetate. This solution was washed in succession with 10% aqueous citric acid, 50% sodium bicarbonate solution, and brine. The organic phase was dried
 30 (sodium sulfate) and concentrated. Chromatography of the crude reaction product on silica gel (1:1 ethyl acetate-hexane elution) afforded the title compound as an amorphous solid: m.p. 82-92°C.

HPLC: >92% pure at 214 nM

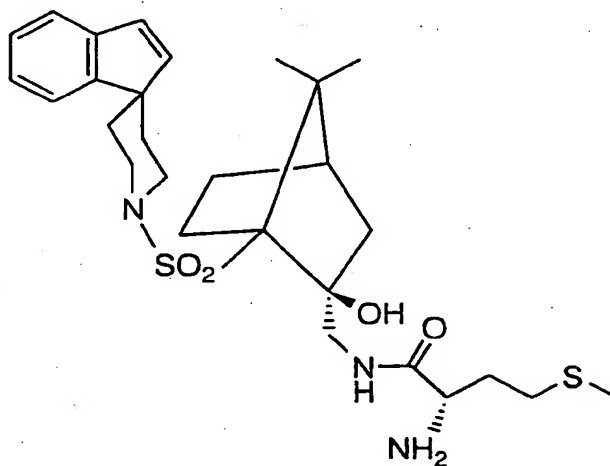
NMR: Consistent with structure and verified presence of solvent

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FAB MS: 670 (M^+ + thioglycerol)Analysis calculated for $C_{34}H_{51}N_3O_6S_2 \cdot 0.5CHCl_3$

C, 57.42; H, 7.19; N, 5.82

Found: C, 57.58; H, 7.50; N, 5.83

EXAMPLE 28

2-amino-N-[[exo-2-hydroxy-7,7-dimethyl-1-[(spiro[1H-indene-1,4'-piperidin]1'ylsulfonyl)methyl]bicyclo]2.2.1]hept-2-yl)methyl]-4-methylthio)-butanamide

A continuous stream of dry HCl gas was passed for 5 minutes into an ice cold solution of ethyl acetate (2 ml) containing 20 mg of the product of Example 27. After 30 minutes at 0°C, the reaction mixture was concentrated and the residue was chromatographed on two 0.25 mm precoated silica gel plates (chloroform-methanol-ammonium hydroxide, 93:7:0.7 v/v elution). The title compound was obtained as a solid (10.7 mg): m.p. 78-80°C.

TLC: R_f =0.28 ($CHCl_3$ - CH_3OH - NH_4OH , 95:5:0.5)

NMR: Consistent with structure and verifies presence of solvent

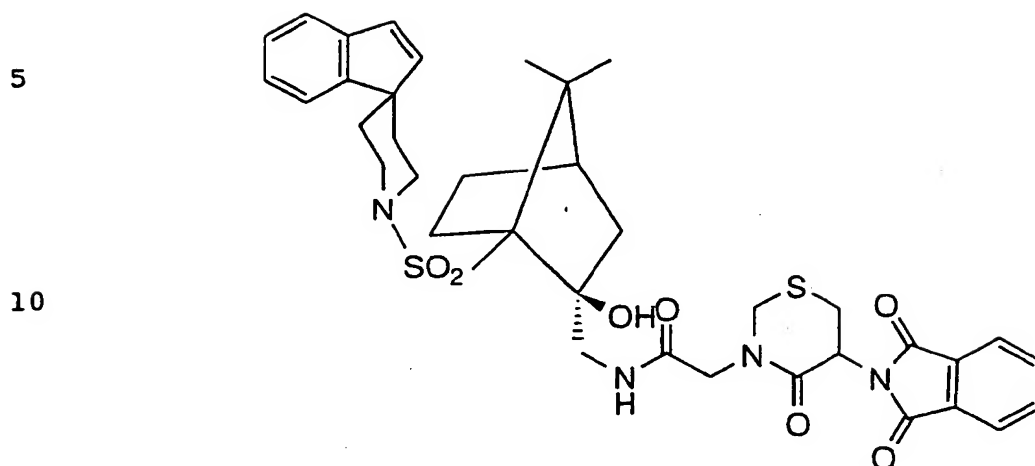
FAB MS: 562 (M^+ +H)

Analysis calculated for $C_{29}H_{43}N_3O_4S_2 \cdot 0.75CHCl_3$

C, 54.86; H, 6.77; N, 6.45

Found: C, 54.52; H, 6.90; N, 6.32

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EXAMPLE 29

15 5-(1,3-dihydro-1,3-dioxo-2H-isoindol-2-yl)-N-[[[2-hydroxy-7,7-dimethyl-1-[(spiro[1H-indene-1,4'-piperidin]-1'-ylsulfonyl)methyl]bicyclo[2.2.1]hept-2-yl]-methyl]dihydro-4-oxo-2H-1,3-Thiazine-3(4H)-acetamide

To a stirred solution of (1S)-1'-(((exo-2-hydroxy-2-aminomethyl-7,7-dimethylbicyclo(2.2.1)hept-1-yl)-sulfonyl)spiro(1H-indene-1,4'-piperidine) (67 mg, 0.16 mmole) in 1.5 ml of dry, degassed N,N-dimethylformamide was added 4-oxo-5-phthalyl-1,3-thiazine-acetic acid (62 mg, 0.192 mmole) and 88 mg (0.20 mmole) of benzotriazol-1-yloxytris(dimethylamino)-phosphonium hexafluorophosphate (BOP) at room temperature. The resulting reaction mixture was protected from moisture and the pH was adjusted to 8-9 with diisopropylethylamine. After 24 hours all volatile components were removed under reduced pressure and the residue was suspended in 5 ml of toluene. Concentration of this suspension afforded the crude product which was chromatographed on silica gel (96:4:0.4 CHCl₃-CH₃OH-NH₄OH) to give the title compound (109 mg): m.p. 134-137° C.

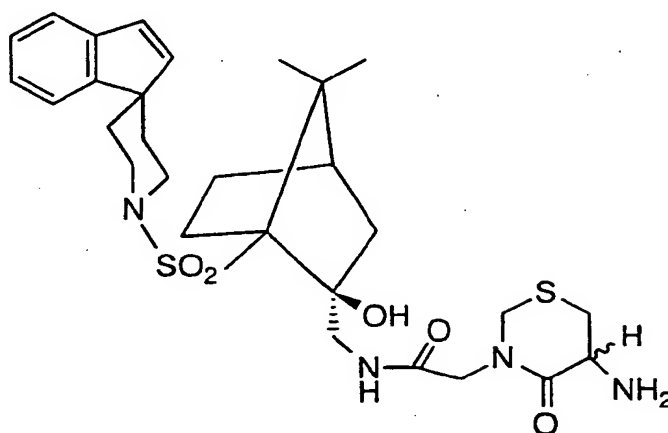
NMR: Consistent with structure and verifies presence of solvent;

HPLC: >94% pure at 214 nM;

FAB MS: 733 (M⁺+H)

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Analysis calculated for $C_{38}H_{44}N_4O_7S_2 \cdot 1.1CHCl_3$
 C, 54.34; H, 5.26; N, 6.48
 Found: C, 54.12; H, 5.22; N, 6.42

EXAMPLE 30

5-amino-N-[[1-[[[spiro[1H-indene-1,4'-piperidin]-1-yl)-sulfonyl]-methyl]-exo-2-hydroxy-7,7-dimethylbicyclo-[1.1.1]hept-2-yl]-methyl]dihydro-4-oxo-2H-1,3-Thiazine-3(4H)-acetamide

The product of Example 29 (60 mg) was dissolved in 3 ml of methanol and treated with 50 ml (1.59 mmole) of 95% hydrazine at 23°C. After 24 hours the solvent was removed under vacuum and the residue was suspended in toluene. Rotoevaporation of this suspension gave the crude product, which was chromatographed on four 0.5 mm procoated silica gel plates (chloroform-methanol-ammonium hydroxide, 92:8:0.8 v/v elution). The title compound was obtained as an amorphous solid (27 mg): m.p. 103-106°C.

NMR: Consistent with structure and verifies presence of solvent

HPLC: >97% pure at 214 nM;

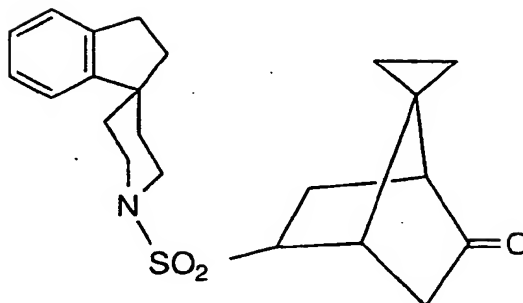
FAB MS: 605 ($M^+ + H$)

Analysis calculated for $C_{30}H_{44}N_4O_5S_2 \cdot 0.6CHCl_3$

C, 54.33; H, 6.64; N, 8.28

Found: C, 54.12; H, 6.60; N, 8.20

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EXAMPLE 31

1'-[(5-oxospiro[bicyclo[2.2.1]heptane-7,1'-cyclopropan]-2-yl)-
sulfonyl]-spiro[1H-indane-1,4'-piperidine]

Spiro(1H-indane-1,4'-piperidine)hydrochloride (3 g, 13.5 mmole) was dissolved in 30 ml of methylene chloride. The resulting solution was cooled to 0°C and treated with 3.76 ml of triethylamine. This was followed by the dropwise addition of chloroethylsulfonylchloride (1.57 ml, 15 mmole). The reaction mixture was allowed to warm to room temperature over one hour and was filtered. The filtrate was washed with water, sodium bicarbonate solution, and brine. The dried organic washings were concentrated and the residue was column chromatographed on silica gel (98:2 methylene chloride-ether elution) to give 1.88 g of 1'-(vinylsulfonyl)spiro(1H-indane-1,4'-piperidine) (m.p. 114-115°C).

1'-(Vinylsulfonyl)spiro(1H-indane-1,4'-piperidine) (185 mg, 0.67 mmole) was combined with 5.1 g (55 mmole) of spiroheptadiene in 4 ml of benzene and heated to reflux for 48 hours. The solvent and excess reagent were removed under reduced pressure and the residual oil was chromatographed on silica gel (4:1 hexane-ethyl acetate elution) to give 216 mg of a solid which was recrystallized from methanol to give white needles (m.p. 176-177°C). Of this material, 110.7 mg was dissolved in 5 ml of dry THF under nitrogen. This solution was cooled to 0°C and treated with 0.1 ml of borane-THF complex. After stirring for one hour, an additional 0.1 ml of Borane-THF complex was added to the reaction mixture and stirring was continued at room temperature for 1 hour more. The reaction mixture was recooled to 0°C and

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quenched with the dropwise addition of water. After 10 minutes, 0.3 ml of 3N sodium hydroxide solution and 0.3 ml of 30% hydrogen peroxide solution was added. The resulting mixture was heated to 50°C for 1 hour and allowed to stand at 23°C overnight. The reaction mixture was partitioned between ethyl acetate and brine. The aqueous phase was extracted with ethyl acetate and the combined organic extracts were dried (MgSO₄) and concentrated. Purification of the crude reaction product by preparative TLC on silica gel (2:1 hexane-ethyl acetate) afforded two components. The more polar product (m.p. 232-233°C, from methanol) (0.15 mmole) was dissolved in 5 ml of methylene chloride and oxidized with pyridinium chlorochromate (2 mmole) at 23°C. The reaction mixture was filtered through celite and the filtrate was applied to 0.25 mm precoated silica gel plates. Elution with 2:1 hexane-ethyl acetate and recrystallization from methanol afforded the title compound as a white solid: m.p. 210-212°C.

NMR: Consistent with structure and verifies presence of solvent

HPLC: >96% pure at 214 nM;

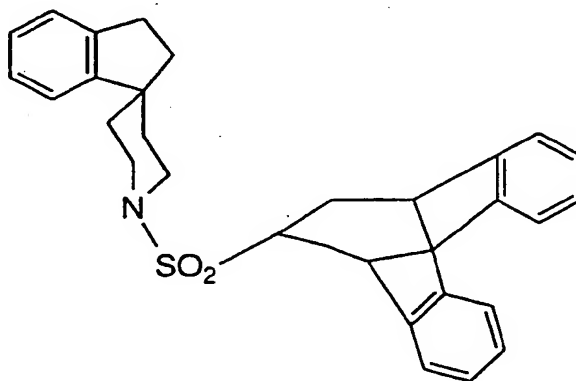
FAB MS: 386 (M⁺+H)

Analysis calculated for C₂₂H₂₇NO₃S·0.3CH₂O

C, 67.59; H, 7.12; N, 3.58

Found: C, 67.66; H, 7.22; N, 3.53

EXAMPLE 32



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1'-[(9,10-dihydro-9,10-ethanoanthracen-1]-yl)sulfonyl]-spiro[1H-indane-1,4'-piperidine]

1'-(Vinylsulfonyl)spiro(1H-indane-1,4'piperidine) (152 mg) was combined with 350 of anthracene in 15 ml of toluene and heated to reflux for 8 days. The solvent and excess reagent was removed under reduced pressure and the residual oil was chromatographed on silica gel (4:1 hexane-ethyl acetate elution) to give the title compound as an amorphous solid.

NMR: Consistent with structure and verifies presence of solvent

HPLC: >99% pure at 214 nM;

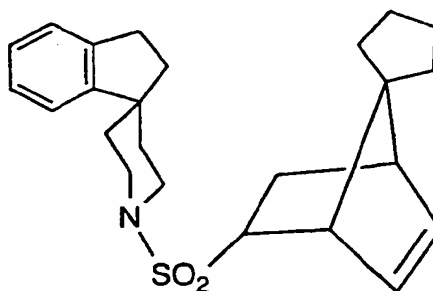
FAB MS: 456 ($M^+ + H$)

Analysis calculated for $C_{29}H_{29}NO_2S \cdot 0.05C \cdot H_2O \cdot 0.25 HCl_3$

C, 72.23; H, 6.08; N, 2.88

Found: C, 72.23; H, 5.92; N, 2.67

EXAMPLE 33



1'-(spiro[bicyclo[2.2.1]hept-5-ene-7,1'-cyclopentan]-2-ylsulfonyl)-spiro[1H-indane-1,4'-piperidine]

1'-(Vinylsulfonyl)spiro(1H-indane-1,4'piperidine) (100 mg) was combined with 500 mg of spirononadiene in 3 ml of toluene and heated to reflux for 17 hours. The solvent and excess reagent were removed under reduced pressure and the residual oil was chromatographed on silica gel (4:1 hexane-ethyl acetate elution) to give the title compound as an amorphous solid: m.p. 115-119°C.

NMR: Consistent with structure and verifies presence of solvent

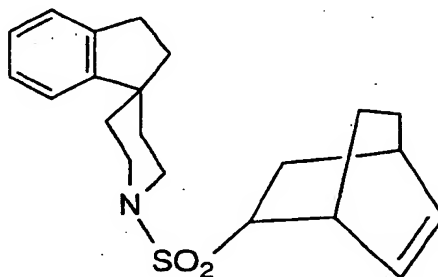
- 105 -

HPLC: >99% pure at 214 nM;

FAB MS: 398 ($M^+ + H$)Analysis calculated for $C_{24}H_{31}NO_2S \cdot 0.05CHCl_3$

C, 71.57; H, 7.76; N, 3.47

5 Found: C, 71.94; H, 7.81; N, 3.42

EXAMPLE 34

15
1'-(bicyclo[2.2.1]hept-5-en-2-ylsulfonyl)spiro[1H-indane-1,4'-
piperidine]

1'-(Vinylsulfonyl)spiro(1H-indane-1,4'piperidine) (100
mg) was combined with ten equivalents of cyclohexadiene in 10 ml of
20 toluene and heated to reflux for 30 hours. The solvent and excess
reagent were removed under reduced pressure and the residual oil was
chromatographed on silica gel (4:1 hexane-ethyl acetate elution) to give
the title compound as an amorphous solid: m.p. 162-166°C.

25 NMR: Consistent with structure and verifies presence of solvent

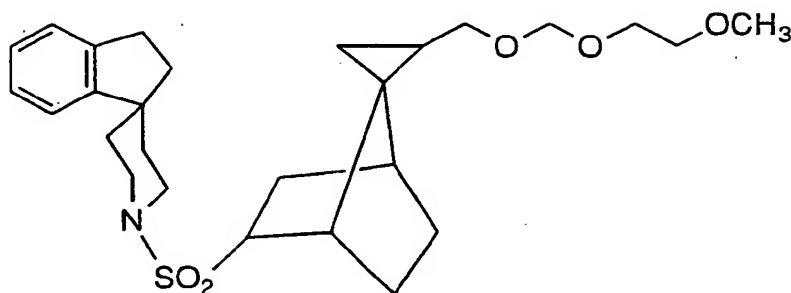
HPLC: >99% pure at 214 nM;

FAB MS: 358 ($M^+ + H$)Analysis calculated for $C_{21}H_{27}NO_2S \cdot 0.1H_2O$

C, 70.19; H, 7.63; N, 3.90

30 Found: C, 70.30; H, 8.03; N, 3.61

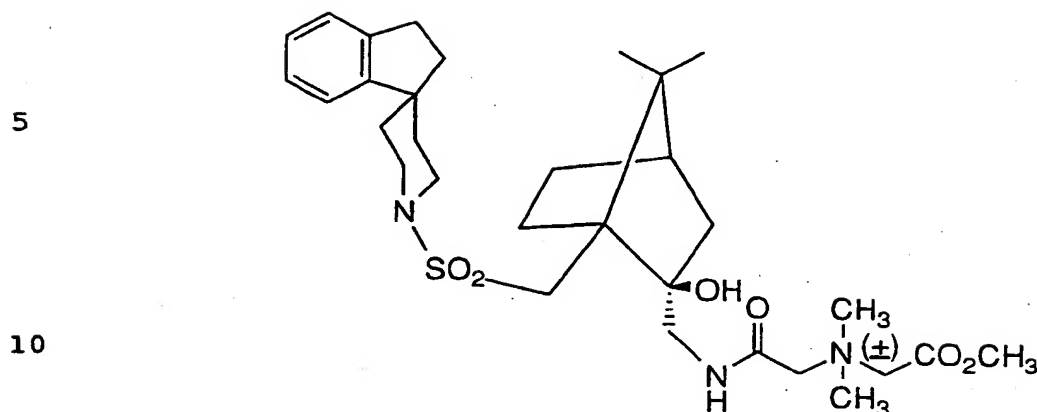
- 106 -

EXAMPLE 35

1'-[[2'-[[[(2-methoxyethoxy)methoxy]methyl]spiro]bicyclo[2.2.1]hept-5-ene-7,1'-cyclopropan]-2-yl]sulfonyl]-spiro[1H-indane-1,4'-piperidine] 1'-(Vinylsulfonyl)spiro(1H-indane-1,4'piperidine) (2.45 g) was combined with 2.2 g of hydroxymethylspirocycloheptadiene and 3 mg of hydroquinone in 8 ml of toluene and heated to reflux for 17 hours. The solvent and excess reagent were removed under reduced pressure and the residual oil was chromatographed on silica gel (1:2 hexane-ethyl acetate elution) to give three components. The least polar of these products (80 mg) was dissolved in methylene chloride containing 78 mg of diisopropylethylamine and treated with 49 mg of 2-methoxyethoxy-methyl chloride. The reaction mixture was protected from moisture and stirred at 23°C overnight. The reaction mixture was concentrated and the residual material was applied to 0.5 mm precoated silica gel plates. Elution with 1:1 hexane-ethyl acetate afforded the title compound.

NMR: Consistent with structure and verifies presence of solvent;
 PLC: >90% pure at 214 nM;
 FAB MS: 488 ($M^+ + H$)

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EXAMPLE 36

(1S)-2-[[[exo-2-hydroxy-7,7-dimethyl-1-[(spiro[1H-indene-1,4'-piperidin]-1'-ylsulfonyl)methyl]bicyclo[2.2.1]hept-2-yl)methyl]amino]-N-(2-methoxy-2-oxoethyl)-N,N-dimethyl-2-oxo-ethanaminium salt with trifluoroacetic acid (1:1)

To a stirred solution of (1S)-1'-(((exo-2-hydroxy-endo-2-aminomethyl-7,7-dimethylbicyclo(2.2.1)hept-1-yl)methyl)sulfonyl)-spiro(1H-indene-1,4'-piperidine) (108 mg, 0.25 mmole) in 5 ml of toluene was added 1 ml of toluene containing 0.5 mmole of methyliminodiacetic acid anhydride. Tetrahydrofuran (2 ml) was added and the white suspension was stirred at 23°C overnight. The reaction mixture was filtered and concentrated. The residue was dissolved in 5 ml of N,N-dimethylformamide and treated in succession with methyl iodide (0.5 ml) and diisopropylethylamine (0.2 ml). The resulting solution was protected from moisture and heated for 5 hours at 50°C. An additional 0.5 ml of methyl iodide was added and heating was continued for 5 hours more. The reaction mixture was concentrated and the residue was purified via reverse phase preparative HPLC (Vydac Protein & Peptide C-18 column, mobile phase = 0.1% trifluoroacetic acid (TFA) in water-acetonitrile). The fractions containing the title compound were pooled and concentrated. The residue was dissolved in dioxane and this solution was freeze-dried to yield the TFA salt of the title compound as a white powder:

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NMR: Consistent with structure and verifies presence of solvent

HPLC: >99% pure at 214 nM;

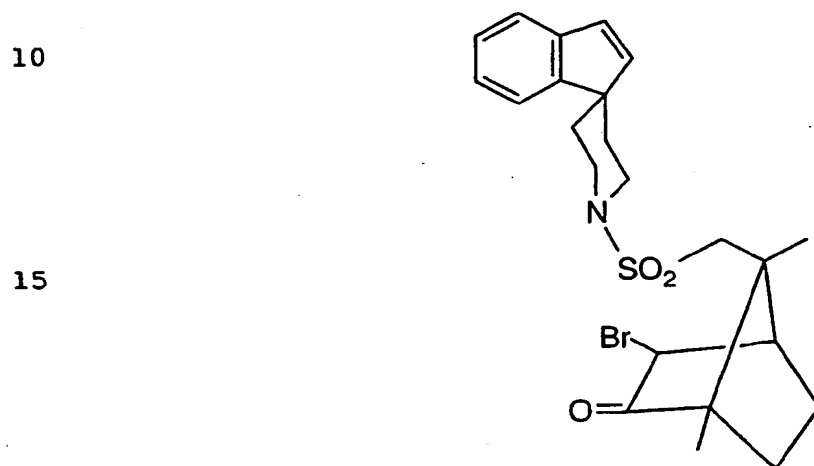
FAB MS: 588 ($M^+ + H$)

Analysis calculated for $C_{31}H_{46}N_3O_6S \cdot 1.8CF_3CO_2H \cdot 1.0$ dioxane

5 C, 52.61; H, 6.27; N, 4.77

Found: C, 52.58; H, 6.40; N, 4.76

EXAMPLE 37

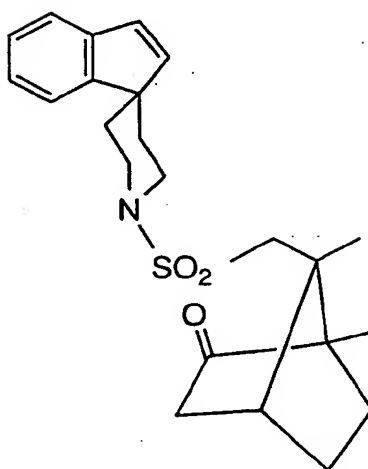


(1R-syn)-1'-[[[(1,7-dimethyl-2-oxobicyclo[2.2.1]hept-7-yl)methyl]-sulfonyl]-spiro[1H-indene-1,4'-piperidine]

25 Dissolved 100 mg (.304 mM; FW=328.23) of (-)-3-bromocamphosulfonic acid ammonium salt in 15 mL of DCM. Added 5 eq of thionylchloride (FW=118.97; d=1.631; 1.52 mM; 120 mL) and allowed mixture to react at 0°C under a N₂ balloon for 1 hour. After 1 hour the mixture was concentrated to obtain 63.12 mg of crude acid chloride (.191 mM).

30 Dissolved 47.13 mg of indene HCl salt in 20 mL of THF. The acid chloride was added along with 2 eq of DIEA, and allowed to react at room temperature for 1 hour, then concentrated and washed with 2 x 200 mL of 1 N NCl, 2 x 200 mL H₂O and 2 x 200 mL brine, then concentrated and dried over sodium sulfate. Flash chromatography in 25% EtOAc/petroleum ether.

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EXAMPLE 38

To a solution of the product of Example 37 (107 mg, 0.300 mmol) in glacial acetic acid (10 mL) was added zinc dust (24 mg, 0.367 mmol). The temperature was then increased to reflux. After 30 minutes the mixture was cooled to room temperature, filtered, then concentrated under reduced pressure. Purification by flash chromatography (35% ethyl acetate in petroleum ether as eluent) afforded 80 mg of the product as a white amorphous foam.

NMR (300 MHz, CDCl_3): Consistent with structure;

HPLC: (Vydac C18 column, gradient from 95/5 to 0/100 $\text{H}_2\text{O}/\text{CH}_3\text{CN}$ with 0.1% TFA, 15 min. gradient, flow rate = 1.5 mL/min.):

Purity: 98%, r.t. = 12.67 min.

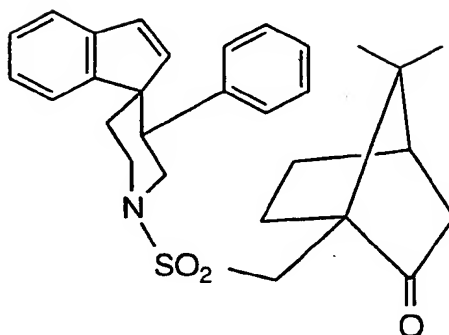
FAB MS: $[\text{M} + 1]^+$ at 400.91

Analysis calculated for $\text{C}_{23}\text{H}_{29}\text{NO}_3\text{S}$

C, 69.13; H, 7.32; N, 3.51

Found: C, 69.25; H, 7.30; N, 3.48

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EXAMPLE 39

1'-[[[(7,7-dimethyl-2-oxobicyclo[2.2.1]hept-1-yl)-methyl]sulfonyl]-3'-phenyl-spiro[1H-indene-1,4'-piperidine]

Ethanolamine (6.66 mL, 0.1103 mmol) was placed in a 3-neck round bottom flask and heated to reflux. Once at reflux, styrene oxide (6.28 mL, 0.0557 mmol) was added dropwise to the reaction mixture over 15 minutes. The reaction mixture was refluxed an additional 2 hours and then allowed to cool. The product, N-(2-hydroxyethyl)-N-(2-hydroxy-2-phenylethyl)amine, was obtained as a clear oil by vacuum distillation.

N-(2-hydroxyethyl)-N-(2-hydroxy-2-phenylethyl)amine (1.30 g, 7.16 mmol) was dissolved in chloroform and then while under a nitrogen blanket, thionyl chloride (1.05 mL, 14.32 mmol) was added dropwise over 10 minutes. The reaction mixture was then refluxed for 1 hour and allowed to cool to room temperature. Water was then added to the mixture and allowed to stir 1 hour. The reaction mixture was separated and the organic layer was washed three times with 3N HCl. The aqueous layers were combined and then basified with 40% sodium hydroxide. The aqueous layer was extracted 3 times with ether, the organics were combined, and dried over sodium sulfate. The organic layer was filtered and the filtrate concentrated to a yellow oil.

The yellow oil was dissolved in ether and then di-t-butyl dicarbonate (1.50 g, 6.87 mmol) was added along with triethylamine (500 mL, 3.59 mmol). The mixture was allowed to stir overnight and then it was washed with H₂O (2x), 0.1N HCl (2x) and sodium bicarbonate (2x). The organic layer was dried over sodium sulfate,

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filtered, and the filtrate concentrated to a yellow oil. The yellow oil was dissolved in CH_2Cl_2 and poured onto a silica gel column. The column was eluted with 1:1 CH_2Cl_2 /hexane. The product fractions were combined and concentrated to dryness to yield the product, N-(2-hydroxyethyl)-N-(2-hydroxy-2-phenylethyl)-t-butyl-carbamate.

To a solution of indene (268 ml, 2.30 mmol) in dry THF (2 mL) cooled in an ice bath and maintained under a nitrogen blanket was added lithium bis(trimethylsilyl)amide (1M solution in THF, 4.6 mL, 4.60 mmol) over 10 minutes. The mixture was stirred in the cold bath for 30 minutes, then added over 10 minutes to a solution of N-(2-hydroxyethyl)-N-(2-hydroxy-2-phenylethyl)-t-butylcarbamate (694 mg, 2.30 mmol) stirred in an ice bath. The mixture was stirred for 2 hours in the cold and for 30 minutes at 25°C under nitrogen, then concentrated to an orange oil. 10% ethyl acetate in hexane was added and the resulting mixture poured onto a silica gel column packed with 10% ethyl acetate in hexane. Elution was with the same solvent and the product fraction were concentrated to provide 1'-(t-butyloxycarbonyl)-spiro-(indene-3'-phenyl-1,4'-piperidine).

1'-(t-Butyloxycarbonyl)spiro(indene-3'-phenyl-1,4'-piperidine) (290.9 mg, 0.842 mmol) in ethyl acetate was stirred in an ice bath and saturated with HCl (g) for 30 minutes. The mixture was concentrated to dryness and reconstituted from ether three times to yield spiro (1H-indene-3-phenyl-1,4'-piperidine)-hydrochloride.

Spiro(1H-indene-3'-phenyl-1,4'-piperidine)hydrochloride (205.2 mg, 0.690 mmol) and (+)-10-camphorsulfonyl chloride (196 mg, 0.782 mmol) were combined in THF and the pH was adjusted to 9 with triethylamine (196 mL, 1.41 mmol). The reaction mixture was stirred overnight at 25°C, then concentrated to dryness, and redissolved in CH_2Cl_2 , then poured onto a silica gel column and eluted with CH_2Cl_2 . The product fractions were combined and evaporated to dryness to provide the title compound which was crystallized from ether and dried in vacuo overnight.

m.p.: 183° - 215°C

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NMR: Consistent with structure

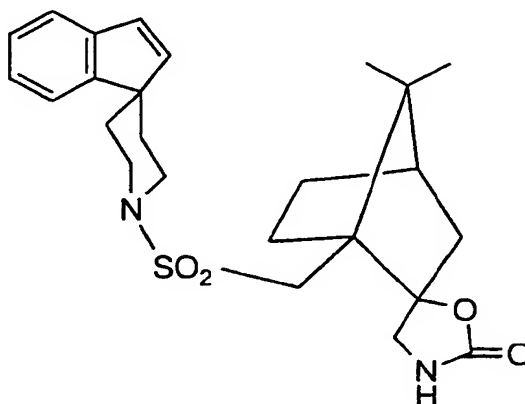
HPLC: >95% pure

MS: M + H 476.3 (FAB)

Analysis calculated for $C_{29}H_{33}NO_3S \cdot 0.50H_2O$

C, 71.86; H, 7.07; N, 2.89

Found: C, 71.88; H, 7.03; N, 2.87

EXAMPLE 40

(1S(1a,2a,4a))-2-hydroxy-7,7-dimethyl-1-((spiro-(1H-indene,1,4'-piperidin)-1'-yl-sulfonyl)methyl)-bicyclo-(2.2.1)heptane-2-acetic acid

(100 mg, 0.217 mmol) diphenylphosphoryl azide (51.5 mL, 0.239 mmol), and triethylamine (66.2 mL, 0.471 mmol) were combined in DMF. The mixture was allowed to stir overnight and then it was concentrated to dryness. The resulting residue was dissolved in CH_2Cl_2 , poured onto a silica gel column, and eluted with 5% methanol in CH_2Cl_2 . The product fractions were combined and concentrated to dryness. The title compound was obtained as a white solid from ether and dried in vacuo overnight.

NMR: Consistent with structure

HPLC: >93% pure

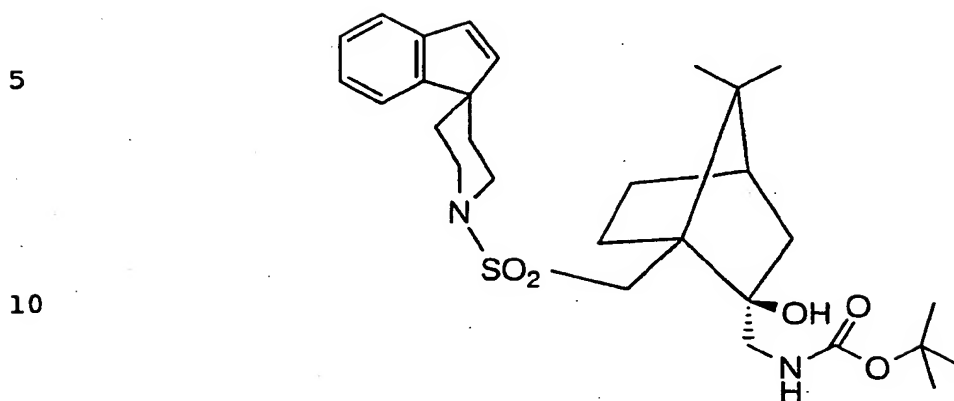
MS: M + H 457.3 (FAB)

Analysis calculated for $C_{25}H_{32}N_2O_4S$

C, 65.76; H, 7.06; N, 6.14

Found: C, 65.76; H, 7.42; N, 5.80

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EXAMPLE 41

15 (1S-exo)-[[2--hydroxy-7,7-dimethyl-1-[(spiro[1H-indene-1,2'-piperidin)-1'-ylsulfonyl)methyl]bicyclo2.2.1]hept-2-yl]carbamic acid 1,1-dimethylethyl ester

(1S)-1'-(((7,7-dimethyl-2-oxobicyclo-(2.2.1)-hept-1-yl)-methyl)sulfonyl)spiro(1H-indene-1,4'-piperidine) (1.92 g, 4.81 mmol) was combined with zinc iodide (47 mg, 0.15 mmol) in 2 mL of toluene. While under a nitrogen atmosphere, the mixture was treated with trimethylsilyl cyanide (960 mL, 7.21 mmol) dropwise. The reaction mixture was then heated to 100°C for 3.5 hours. The mixture was allowed to cool and diluted with 10 mL of dry THF. Then lithium aluminum hydride (1M in THF; 8.6 mL, 8.6 mmol) was added dropwise over 5 minutes and the mixture was allowed to stir at 25°C for 2 hours. The reaction mixture was then diluted with ether (N50 mL) and 10% sodium hydroxide solution was added dropwise until a gray precipitate stopped forming. The mixture was now filtered, the filtrate was washed with sodium bicarbonate and brine, the organic layer was separated and dried over sodium sulfate. The organic layer was filtered, the filtrate concentrated and the residue dissolved in CH₂Cl₂. This was poured onto a silica gel column, eluted with 97/3/0.3 of CH₂Cl₂/methanol/ ammonium hydroxide and product fractions collected. The product fractions were combined and concentrated to dryness. The desired product, (1S)-1'-(((7,7-dimethyl-(2-endo-aminomethyl-2-exo-hydroxy)-

20

25

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bicyclo-(2.2.1)-hept-1-yl)-methyl)-sulfonyl)spiro(1H-indene-1,4'-piperidine), was obtained as a white foam from ether.

(1S)-1'-(((7,7-dimethyl-(2-endo-aminomethyl-2-exo-hydroxy)-bicyclo-(2.2.1)-hept-1-yl)-methyl)-sulfonyl)spiro(1H-indene-1,4'-piperidine) (44.9 mg, 0.104 mmol) and di-t-butyl dicarbonate (25 mg, 0.115 mmol) were combined in 5 mL of CH₂Cl₂. The reaction mixture was treated with triethylamine (18.1 mL, 0.13 mmol) and then stirred for 30 minutes at 25°C. The reaction mixture was poured onto a silica gel column and eluted with 15% ethyl acetate in hexane. The product fractions were combined and evaporated to dryness. The title compound was obtained as a white solid from CH₂Cl₂/hexane and was dried in vacuo overnight.

m.p.: 71°C-115°C

NMR: Consistent with structure

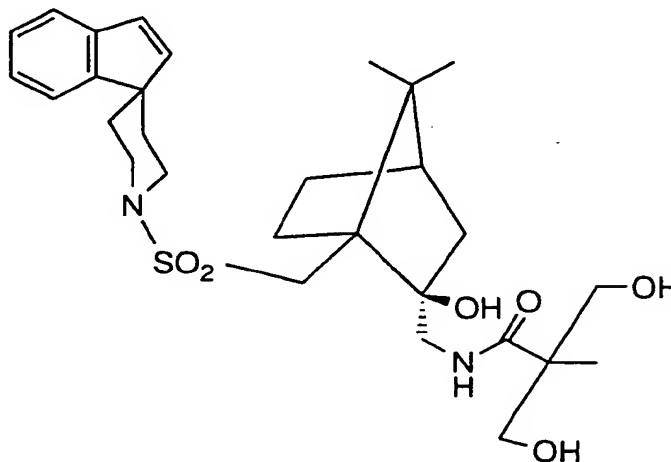
HPLC: >95% pure

Analysis calculated for C₂₉H₄₂N₂O₅S 0.45

C, 66.14; H, 8.73; N, 5.03

Found: C, 66.21; H, 8.52; N, 4.75

EXAMPLE 42



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(1S-exo)-3-hydroxy-N-[[2-hydroxy-7,7-dimethyl-1-[(spiro[1H-indene-1,4'-piperidin]-1'-yl)sulfonyl)methyl]bicyclo[2.2.1]hept-2-yl)methyl]-2-(hydroxymethyl)-2-methyl-propanamide

5 (1S)-1'-(((7,7-dimethyl-(2-endo-aminomethyl-2-exo-hydroxy)-bicyclo-(2.2.1)-hept-1-yl)-methyl)-sulfonyl)spiro(1H-indene-1,4'-piperidine) (51 mg, 0.118 mmol), 2,2-bis(hydroxymethyl)-propionic acid (19 mg, 0.142 mmol), 1-hydroxybenzotriazole hydrate (HBT) (19 mg, 0.142 mmol), and 1-ethyl-3-(dimethylaminopropyl) carbodiimide•HCl(EDC) (27 mg, 0.142 mmol) were all combined in 5
10 mL of DMF. Then, triethylamine (46 mL, 0.33 mmol) was added to adjust the pH to 9, and the mixture was allowed to stir overnight at 25°C. The reaction mixture was concentrated to dryness and treated with 5% citric acid solution. The water layer was then basified with saturated sodium bicarbonate and extracted 3 times with ethyl acetate.
15 The organics were combined and dried over sodium sulfate. The organic layer was filtered, the filtrate concentrated, and the resulting residue dissolved in CH₂Cl₂. This was then poured onto a silica gel column and eluted with 3% methanol in CH₂Cl₂. The product fractions were combined and evaporated to dryness. The title compound was
20 obtained as a white solid from CH₂Cl₂/hexane and was dried in vacuo overnight.

m.p.: 167-170°C

NMR: Consistent with structure

25 HPLC: >99% pure

MS: M + H 547.3 (FAB)

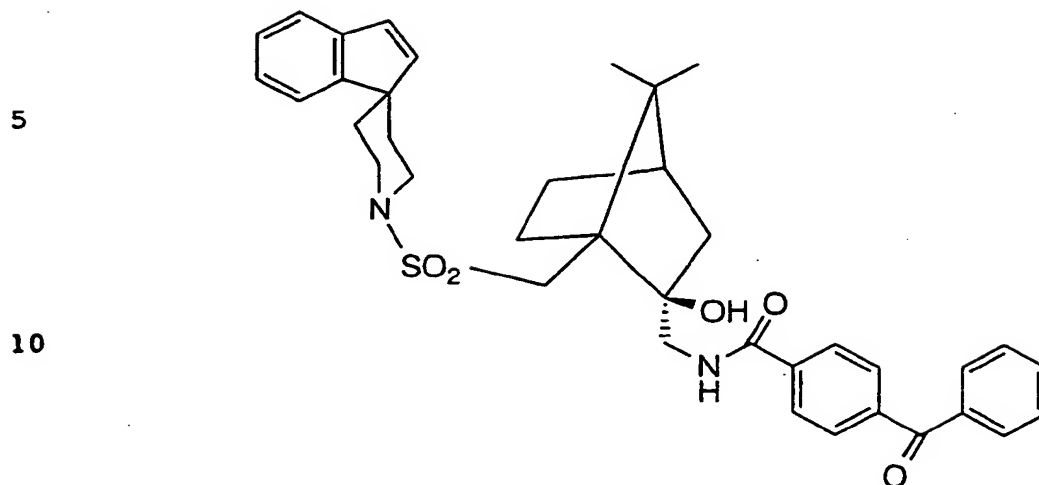
Analysis calculated for C₂₉H₄₂N₂O₆S

C, 63.71; H, 7.74; N, 5.12

Found: C, 63.65; H, 7.59; N, 4.88

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EXAMPLE 43

15 (1S-exo)-4-benzoyl-N-[[2-hydroxy-7,7-dimethyl-1-[(spiro[1H-indene-1,4'-piperidin]-1'-yl)sulfonyl)methyl]bicyclo[2.2.1]hept-2-yl)methyl]-benzamide

The procedure of Example 42 was carried out using 49.6 mg, 0.115 mmol of (1S)-(((7,7-dimethyl-(2-endo-aminomethyl-2-exo-hydroxy)-bicyclo-(2.2.1)-hept-1-yl)-methyl)sulfonyl)spiro(1H-indene-1,4'-piperidine), 26.5 mg, 0.138 mmol of EDC, 18.7 mg, 0.138 mmol of HBT, 48 mL, 0.345 mmol of triethylamine, and substituting 4-benzoylbenzoic acid (31.3 mg, 0.138 mmol) for 2,2-bis-(hydroxymethyl)-propionic acid. Chromatographic elution was with 2% methanol in CH₂Cl₂. The title compound was obtained and dried in vacuo, overnight.

m.p.: 110-135°C

NMR: Consistent with structure

HPLC: >94% pure

30 MS: M + H 639 (FAB)

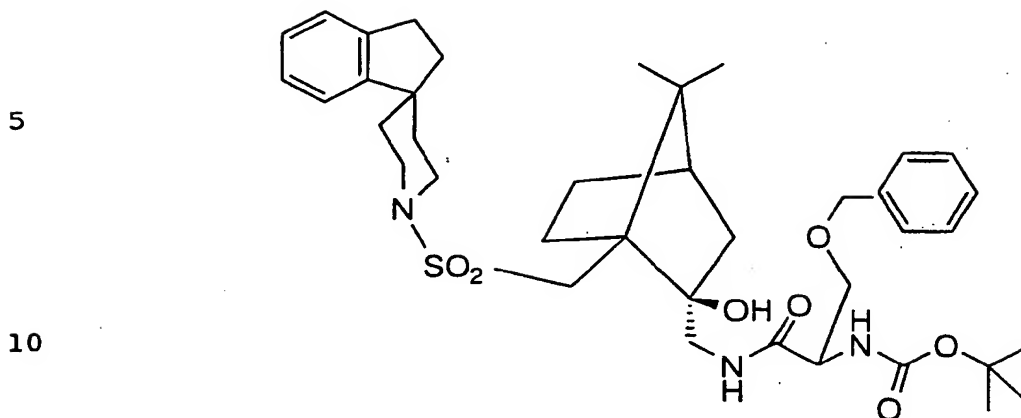
Analysis calculated for C₃₈H₄₂N₂O₅S0.40C₆H₁₄

C, 72.06; H, 7.13; N, 4.16

Found: C, 72.01; H, 7.14; N, 4.18

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EXAMPLE 44



1'-(bicyclo[2.2.1]hept-5-en-2-ylsulfonyl)spiro[1H-indane-1,4'-piperidine]

15 The procedure of Example 42 was carried out using 94.5 mg, 0.22 mmol of (1S)-(((7,7-dimethyl-(2-endo-amino-methyl-2-exo-hydroxy)-bicyclo-(2.2.1)-hept-1-yl)-methyl)-sulfonyl)spiro(1H-indene-1,4'-piperidine), 49.8 mg, 0.26 mmol of EDC, 35.2 mg, 0.26 mmol of HBT, 90 mL, 0.66 mmol of triethylamine, and substituting t-boc-L-serine(bzl) (76.8 mg, 0.26 mmol) for 2,2-bis-(hydroxymethyl)-
20 propionic acid. Chromatographic elution was with 98/2 of CH₂Cl₂/methanol/ammonium hydroxide. The title compound was obtained as a white solid from ether and dried in vacuo overnight.

25 m.p.: 75-95°C

NMR: Consistent with structure

HPLC: >98% pure

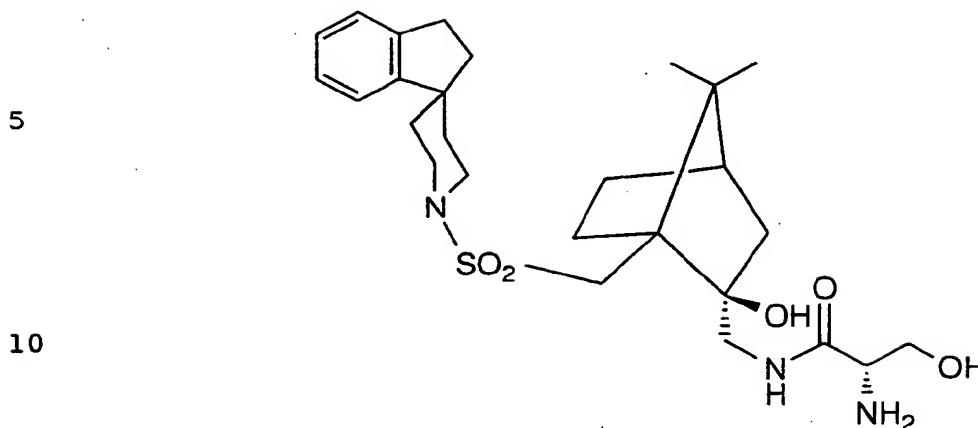
MS: M + H 639 (FAB)

Analysis calculated for $C_{39}H_{53}N_3O_7S$

30 C, 66.16; H, 7.55; N, 5.94

Found: C, 66.04; H, 7.68; N, 5.84

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EXAMPLE 45

15 [1S-[1.alpha., 2 Beta., 2(R*), 4. beta.]]-2-amino-N[[1-[[[(2,3-dihydro spiro[1H-indene-1,4'-piperidin]-yl)sulfonyl]methyl]-2-hydroxy-7,7-dimethylbicyclo[2.2.1]hept-2-yl]methyl]-3-hydroxy-propanamide

The product of Example 44 (120 mg, 0.17 mmol) was dissolved in 4% formic acid in methanol. Palladium hydroxide catalyst (25 mg) was added to the solution and it was placed on a PARR apparatus under 50 p.s.i. of hydrogen, overnight. The reaction mixture was filtered over solka floc and the filtrate was concentrated to a clear oil. This clear oil was dissolved in 2 mL of ethyl acetate and chilled to 0°C. At this point, 5 mL of prechilled sat'd HCl/ethyl acetate solution was added dropwise. The reaction mixture was allowed to stir for 1 hour and then concentrated to dryness. The resulting residue was partitioned between ethyl acetate and saturated sodium bicarbonate, and after extracting 3 times with ethyl acetate, the organics were combined and dried over sodium sulfate. The organic layer was filtered, the filtrate was concentrated, and the resulting residue was dissolved in CH₂Cl₂. This was then poured onto a silica gel column and eluted with 95/5/0.5 of CH₂Cl₂/methanol/ammonium hydroxide. The product fractions were combined and evaporated to dryness. The title compound was obtained as a white solid from ether and dried in vacuo overnight.

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m.p.: 70-110°C

NMR: Consistent with structure

HPLC: >93% pure

MS: M + H 520.3 (FAB)

5 Analysis calculated for C₂₇H₄₁N₃O₅S0.25 C₄H₁₀

C, 61.31; H, 8.20; N, 7.67

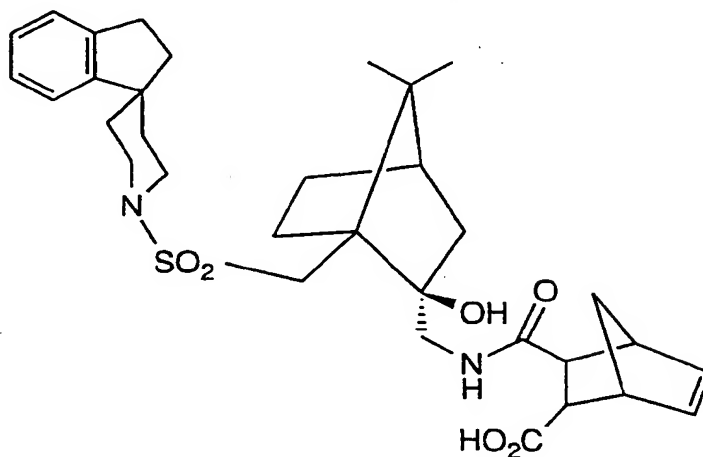
Found: C, 61.35; H, 8.11; N, 7.58

EXAMPLE 46

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3-[[[2-hydroxy-7,7-dimethyl-1-[(spiro[1H-indene-1,4'-piperidin]-1'-ylsulfonyl)methyl]bicyclo[2.2.1]-hept-2-yl)methyl]amino]carbonyl]-bicyclo[2.2.1]hept-5-ene-2-carboxylic acid

25

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(1S)-(((7,7-dimethyl-(2-endo-aminomethyl-2-exo-hydroxy)-bicyclo-(2.2.1)-hept-1-yl)-methyl)sulfonyl)spiro(1H-indene-1,4'-piperidine) (98.5 mg, 0.23 mmol) was combined with bicyclo (2.2.1)-5-heptene-2,3-dicarboxylic anhydride (43 mg, 0.26 mmol) in 5 mL of THF. Triethylamine (50 mL, 0.36 mmol) was added to the reaction dropwise to adjust the pH to 9. The reaction mixture was stirred overnight and then concentrated to dryness. The resulting residue was dissolved in CH₂Cl₂, poured onto a silica gel column, and eluted with 97/3/0.3 of chloroform/methanol/acetic acid. The product fractions were combined and concentrated to dryness. The title

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compound was obtained as a white solid from ether and dried in vacuo overnight.

m.p.: 128-165°C

5 NMR: Consistent with structure

HPLC: >95% pure

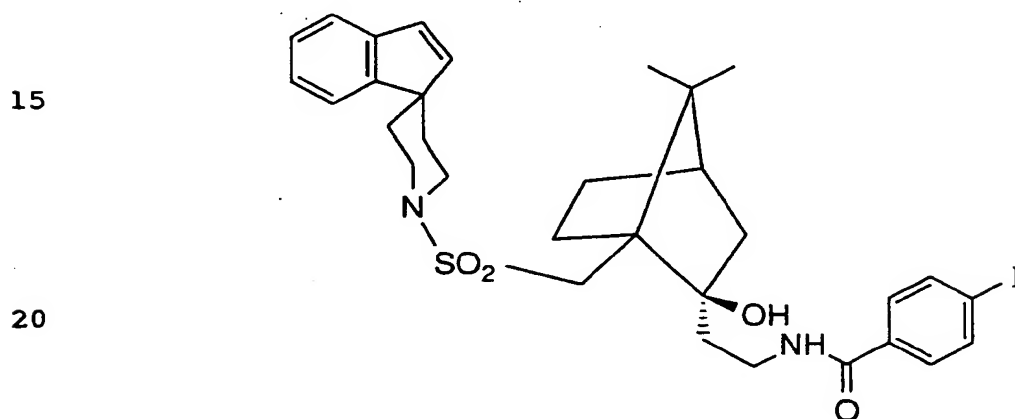
MS: M + H 595 (FAB)

Analysis calculated for C₃₃H₄₂N₂O₆S0.10 CH₂Cl₂

C, 64.74; H, 7.12; N, 4.56

10 Found: C, 64.76; H, 7.07; N, 4.66

EXAMPLE 47



25 (1S)-1'-(((2-endo-cyanomethyl-7,7-dimethyl-exo-2-hydroxybicyclo(2.2.1)-hept-1-yl)methyl)sulfonyl)-spiro(1H-indene-1,4'-piperidine)

Lithium bis(trimethylsilyl)amide (21.3 ml of a 1.0M THF solution, 21.3 mmol) was cooled to -78°C under N₂, treated with acetonitrile (1.07 ml, 20.4 mmol) and stirred 15 minutes. A THF solution (30 mL) of (1S)-1'-(((7,7-dimethyl-2-oxobicyclo(2.2.1)-hept-1-yl)methyl)sulfonyl)spiro(1H-indene-1,4'-piperidine) (40 gm, 10 mmol) was added dropwise and stirred 10 minutes after addition was complete. 6N HCl (2.8 ml) was added to the cold reaction all at once and the mixture was allowed to warm to 25°C.

30

The mixture was diluted with H₂O (25 ml) and extracted with EtOAc (3 x 100 ml). The organic layers were combined, washed

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with H₂O (25 ml) and brine (25 ml), dried over Na₂SO₄, filtered and concentrated to dryness in vacuo. Trituration with ether gave the title compound (4.17 gm, 93% yield) as a crystalline solid (m.p. 199-202°C).

5 TLC: R_f = 0.69, Silica GF (7% Et₂O in CH₂Cl₂)
PMR : Consistent with structure

(1S)-1'-(((2-endo-aminoethyl-7,7-dimethyl-2-exo-hydroxybicyclo-
10 (2.2.1)-hept-1-yl)methyl)sulfonyl)spiro(1H-indene-1,4'-piperidine)

Under a blanket of nitrogen, Lithium Aluminum Hydride (8.0 ml, 8.0 mmol, of a 1.0 M THF solution) was cooled to 0°C, treated dropwise with a THF solution (37 ml) of (1S)-1'-(((2-endo-cyano-methyl-7,7-dimethyl-2-hydroxybicyclo-(2.2.1)-hept-1-yl)methyl)-sulfonyl)spiro(1H-indene-1,4'-piperidine) (4.4 gm, 10.0 mmol) and the
15 reaction stirred 10 minutes. With rapid stirring, the reaction was treated with H₂O (0.37 ml), 20% NaOH (aq) (0.40 ml) and H₂O (1.46 ml) followed by extraction with EtOAc (3 x 150 ml). The organic layers were combined, washed with H₂O (25 ml) and brine (25 ml), dried over Na₂SO₄, filtered and concentrated to dryness in vacuo.

20 Flash chromatography on silica gel (90/10/1/1 of CH₂Cl₂/MeOH/H₂O/HOAc) provided product fractions which were pooled and concentrated to dryness. The residue was treated with sat'd Na₂CO₃ (aq) and extracted with EtOAc (3 x 100 ml). The organic layers were combined, washed with H₂O (25 ml) and brine (25 ml),
25 dried over Na₂SO₄, filtered and concentrated to dryness to give the title compound (2.55 gm, 57% yield) as a white foam/solid.

TLC: R_f = 0.27 Silica GF (90/10/1/1 of CH₂Cl₂/MeOH/H₂O/HOAc)
30 PMR: Consistent with structure

(1S)-1'-(((2-endo-aminoethyl-7,7-dimethyl-2-exo-hydroxybicyclo-(2.2.1)-hept-1-yl)methyl)sulfonyl)-spiro(1H-indene-1,4'-piperidine) (60 mg, 0.135 mmol) was dissolved in CH₂Cl₂ (1 ml), treated with 4-iodobenzoyl chloride (36.0 mg, 0.135 mmol) and Et₃N

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to adjust the pH to 9.5. The reaction was stirred 30 minutes at 25°C and flash chromatographed on silica gel (8% Et₂O in CH₂Cl₂) to give the title compound (45 mg, 50% yield) as a white foam from Et₂O (m.p. 98-138°C, shrinks).

5

TLC: R_f = 0.35 Silica GF (10% Et₂O in CH₂Cl₂)

PMR: Consistent with structure

HPLC: 95.8% pure

M.S.: (FAB) M + H + Thioglycerol = 783

10 Analysis calculated for C₃₂H₃₉IN₂O₄S0.30C₄H₁₀O;0.35 H₂O

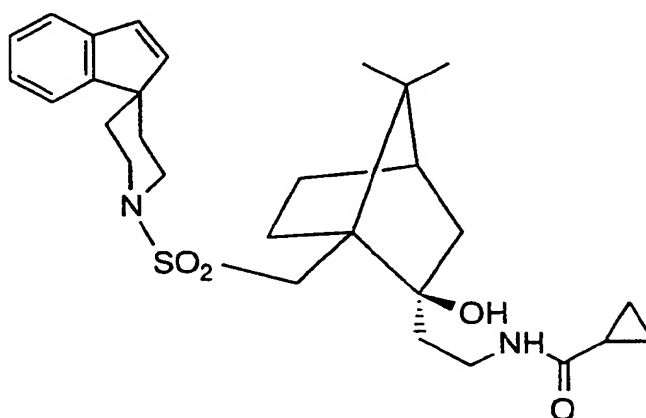
C, 56.70; H, 6.12; N, 3.98

Found: C, 56.73; H, 6.11; N, 4.01

EXAMPLE 48

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20



25

(1S-exo-N-[2-[2-hydroxy-7,7-dimethyl-1-[(spiro[1H-indene-1,4'-piperidin]1'-ylsulfonyl)methyl]bicyclo[2.2.1]hept-2-yl]ethyl]-cyclopropanecarboxamide

30

The title compound was prepared according to the procedure of Example 47 except that cyclopropylcarbonyl chloride (12.4 ml, 0.135 mmol) was substituted for 4-iodobenzoyl chloride.

Flash chromatography of the reaction mixture on silica gel (15% Et₂O in CH₂Cl₂) gave the title compound (36.6 mg, 53% yield) as a white foam from Ether (m.p. 93-105°C shrink + foam).

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TLC: R_f = 0.22 Silica GF (15% Et₂O in CH₂Cl₂)

PMR: Consistent with Structure

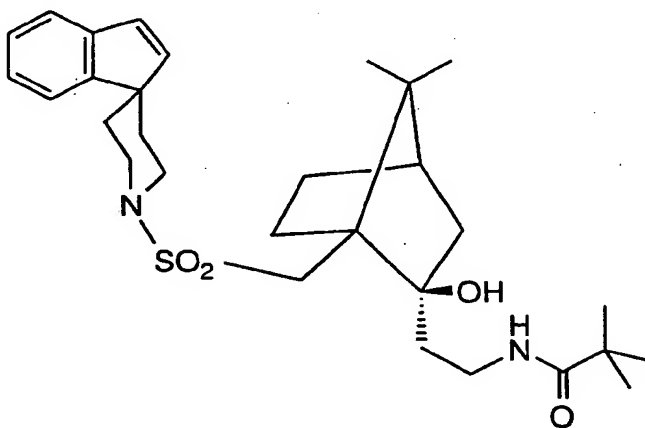
HPLC: 96.8%

M.S.: (FAB) M + H + Thioglycerol = 621

5 Analysis calculated for Calc'd for C₂₉H₄₀N₂O₄S0.20C₇H₁₀O

C, 67.84; H, 8.03; N, 5.31

Found: C, 67.69; H, 8.06; N, 5.06

EXAMPLE 49

(1S-exo)-N-[2-[2-hydroxy-7,7-dimethyl-1-[(spiro[1H-indene-1,4'-piperidin-1'-ylsulfonyl)Methyl]bicyclo[2.2.1]hept-2-yl]ethyl]-2,2-dimethyl-propanamide

25 The title compound was prepared according to the procedure of Example 47 except that trimethyl acetyl chloride (16.6 ml, 0.135 mmol) was substituted for 4-iodobenzoyl chloride.

Flash chromatography of the reaction on silica gel (13% Et₂O in CH₂Cl₂) gave the title compound (32.8 mg, 46% yield) as a white foam from Et₂O (m.p. 78-104°C, shrink + foam).

30

TLC: R_f = 0.29 Silica GF (15% Et₂O in CH₂Cl₂)

PMR: Consistent with structure

HPLC: 97.6%

M.S.: (FAB) M + H + Thioglycerol = 637

Analysis calculated for C₃₀H₄₄N₂O₄S0.20C₄H₁₀O0.30 H₂O =

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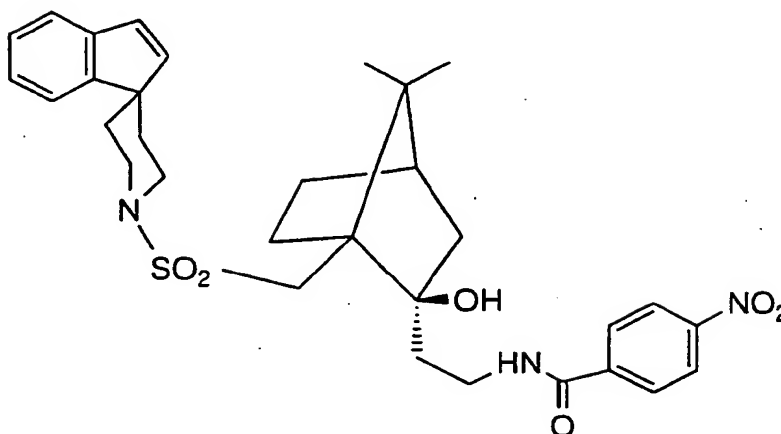
Found: C, 67.38; H, 8.56; N, 5.10
C, 67.37; H, 8.52; N, 5.02

EXAMPLE 50

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(1S-exo)-N-[2-[2-hydroxy-7,7-dimethyl-1-[(spiro[1H-indene-1,4'-piperidin]-1'-ylsulfonyl)methyl]bicyclo[2.2.1]hept-2-yl]ethyl]-4-methoxy-benzamide

The title compound was prepared according to the procedure of Example 47 except that 4-nitrobenzoyl chloride (25.1 mg, 0.135 mmol) was substituted for 4-iodobenzoyl chloride.

Flash chromatography of the reaction on silica gel (10% Et₂O in CH₂Cl₂) gave the title compound (41.6 mg, 52% yield) as a white foam from Ether (m.p. 118-33°C, shrink + foam).

25

TLC: R_f = 0.26 Silica GF (10% Et₂O in CH₂Cl₂).

PMR: Consistent with structure

HPLC: 97.1%

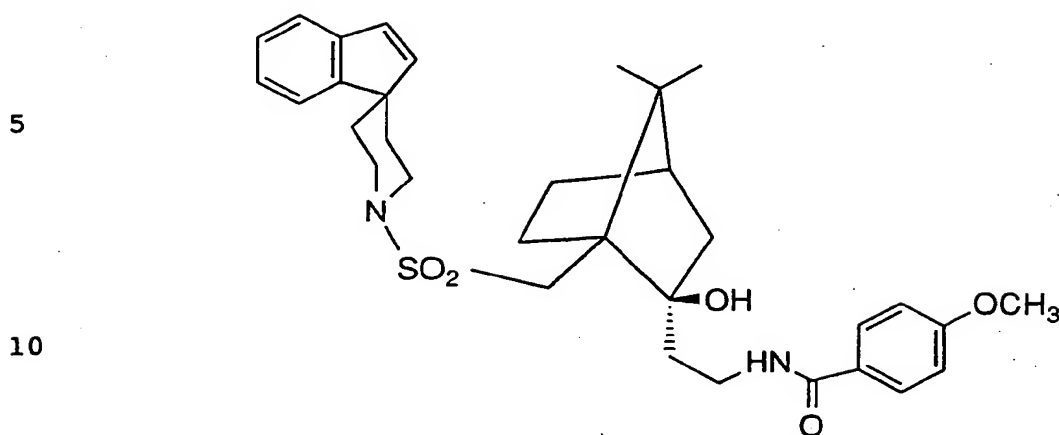
M.S.: (FAB) M + H + Thioglycerol = 702.

30 Analysis calculated for C₃₂H₃₉N₃O₆S_{0.30}C₄H₁₀O_{0.20}H₂O

C, 64.35; H, 6.90; N, 6.78

Found: C, 64.32; H, 6.98; N, 6.63

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EXAMPLE 51

15 (1S-exo)-N-[2-[2-hydroxy-7,7-dimethyl-1-[(spiro[1H-indene-1,4'-piperidin]-1'-ylsulfonyl)methyl]ethyl]bicyclo[2.2.1]hept-2-yl]ethyl[4-methoxybenzamide

The title compound was prepared according to the procedure of Example 47 except that p-anisoyl chloride (18.3 ml, 0.135 mmol) was substituted for 4-iodobenzoyl chloride.

20 Flash chromatography of the reaction on silica gel (15 % Et₂O in CH₂Cl₂) gave the title compound (36 mg, 46% yield) as a white solid from Et₂O (m.p. 98-121°C, shrink).

TLC: R_f = 0.26 Silica GF (15% Et₂O in CH₂Cl₂).

PMR: Consistent with structure

25 HPLC: 95.5%

M.S.: M + H + Thioglycerol = 687

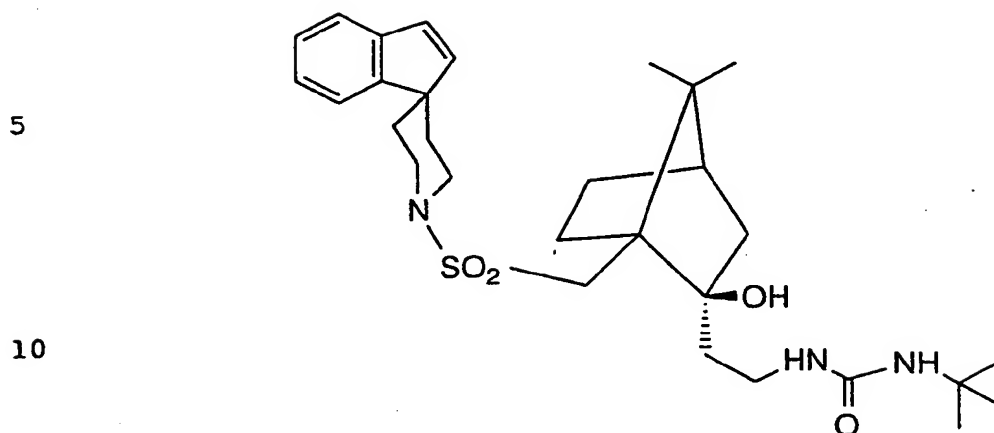
Analysis calculated for C₃₃H₄₂N₂O₅S_{0.25} C₄H₁₀O

C, 68.36; H, 7.51; N, 4.69

Found: C, 68.14; H, 7.67; N, 4.55

30

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EXAMPLE 52

15 (1S-exo)-1'-[[[2-[2-[[[(1,1-dimethylethyl)amino]-carbonyl]amino]-ethyl]-2-hydroxy-7,7-dimethylbicyclo-[2.2.1]hept-1-yl]methyl]-sulfonyl]-spiro[1H-indene-1,4'-piperidine]

(1S)-1'-[[[endo-aminoethyl-7,7-dimethyl-exo-hydroxy-bicyclo(2.2.1)-hept-1-yl]methyl]sulfonyl]spiro(1H-indene-1,4'-piperidine) (60 mg, 0.135 mmol) was dissolved in THF (2 ml), treated with t-butyl isocyanate (15.4 ml, 0.135 mmol) and stirred 30 minutes at 25°C.

25 After removal of the solvent in vacuo, the residue was flash chromatographed on silica gel (25% Et₂O in CH₂Cl₂) to give the title compound (27.9 mg, 38% yield) as a white solid from Et₂O (m.p. 97-119°C, shrink and foam).

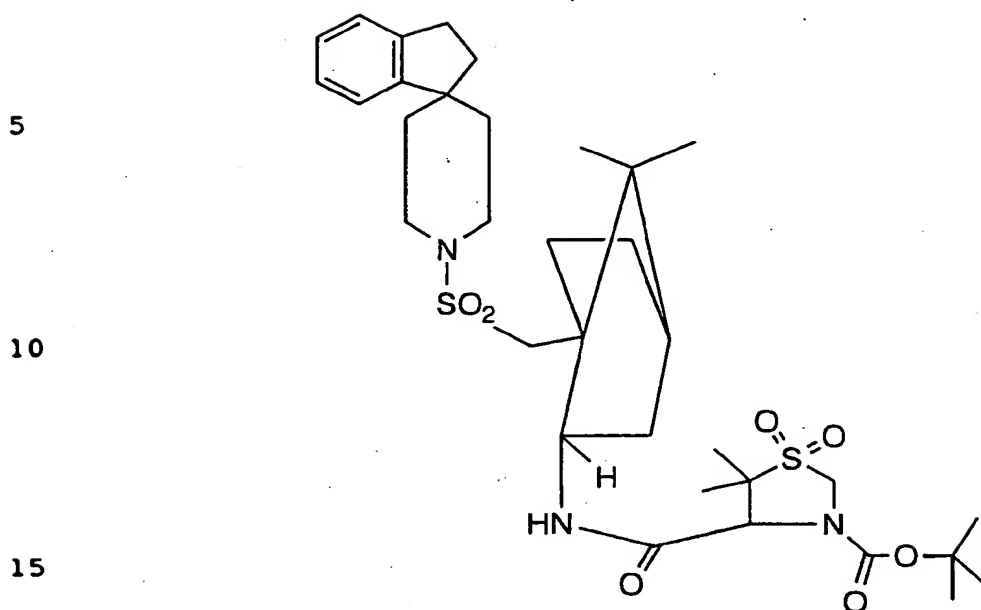
TLC: R_f = 0.21 Silica GF (20% Et₂O in CH₂Cl₂)

PMR: Consistent with structure

HPLC: 95.1%

30 M.S.: (FAB) M + H + Thioglycerol = 652
 Analysis calculated for C₃₀H₄₅N₃O₄S0.25C₄H₁₀O0.30 H₂O
 C, 65.58; H, 8.54; N, 7.40
 Found: C, 65.70; H, 8.74; N, 7.05

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EXAMPLE 53

To a stirred solution of 10 ml of dry N,N-dimethyl-formamide containing endo(1S)-1'-(((2-amino-7,7-dimethyl-bicyclo(2.2.1) hept-1-yl)methyl)sulfonyl)-spiro(1H-indane-1,4'-

20 piperidine) (670 mg, 1.66 mmole) and Na^a-tert-butyloxycarbonyl-5,5-dimethyl-L-thiazolidine-4-carboxylic acid (500 mg, 1.91 mmole) was added 932 mg (2.11 mmole) of benzotriazol-1-yloxytris (dimethyl-amino)phosphonium hexafluorophosphate. The pH of the reaction

25 mixture was adjusted to 8.5 with diisopropylethylamine and the reaction mixture was stirred at 23°C overnight. The reaction mixture was filtered and concentrated under reduced pressure. The residue was dissolved in ethyl acetate and this solution was washed in succession with

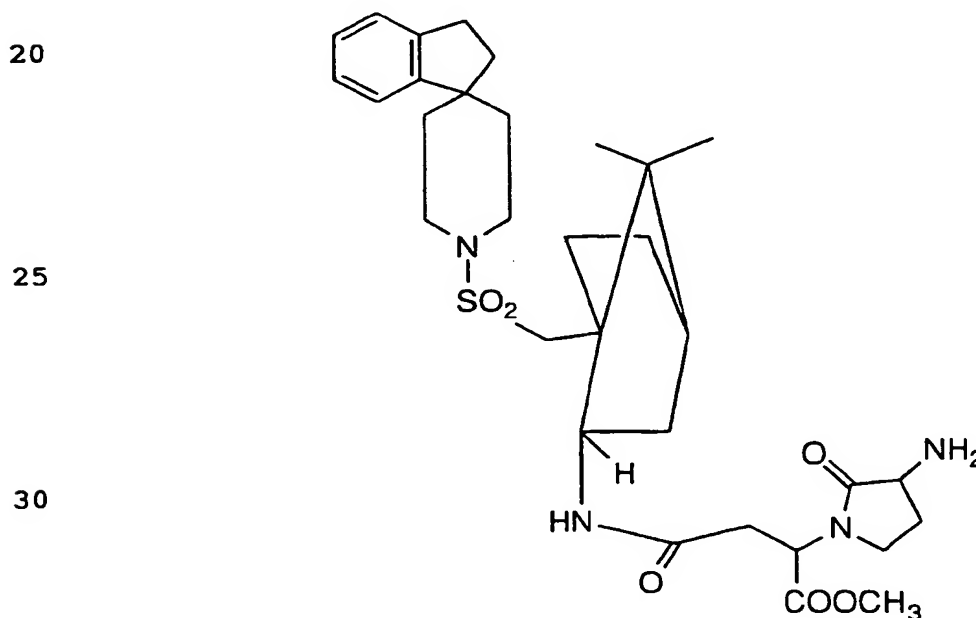
30 saturated sodium bicarbonate solution (3 X 25 ml) and brine. The organic phase was dried (sodium sulfate) and concentrated to yield a brown solid which was purified by chromatography on silica gel (chloroform-methanol-concentrated ammonium hydroxide elution, 98:2:0.2 v/v) to yield a white solid. This material was dissolved in 10 ml of chloroform. The solution was cooled in an icebath and treated dropwise with a solution of 5 ml of chloroform containing 2.2

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equivalents of m-chloroperoxy-benzoic acid. After addition was complete the ice bath was removed and stirring was continued for 24 hours. The reaction mixture was diluted to 100 ml with chloroform and was washed with 1M sodium hydroxide solution (2 X 30 ml) and brine. The organic phase was dried (sodium sulfate) and concentrated under reduced pressure. The crude product was purified by chromatography on silica gel (chloroform-methanol-concentrated ammonium hydroxide elution, 98:2:0.2 v/v) to yield the title compound:

NMR: Consistent with structure and verifies presence of solvent;
HPLC: >94% pure at 214 nM;
FAB MS: 678 ($M^+ + H$);
Elem Analysis calculated for $C_{34}H_{51}N_3O_7S_2 \cdot 0.8CHCl_3$
C, 54.04; H, 6.75; N, 5.43
Found: C, 54.11; H, 6.64; N, 5.48

EXAMPLE 54



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Endo(1S)-1'-(((2-amino-7,7-dimethylbicyclo(2.2.1)hept-1-yl)methyl)sulfonyl)spiro(1H-indane-1,4'-piperidine)(660 mg, 2.05 mmole) and (S)-3-[(tert-butyloxycarbonyl)amino]-2-oxo-1-pyrrolidine-(R)-2-methylcarboxysuccinic acid (826.5 mg, 2.05 mmole) were
5 combined with 392 mg (2.05 mmole) of 1-ethyl-3-(3-dimethylamino-propyl) carbodiimide hydrochloride and 275 mg (2.05 mmole) of 1-hydroxybenzotriazole hydrate in 20 ml of dry methylene chloride at room temperature under nitrogen. The pH of the reaction mixture was adjusted to 8.5 with triethylamine and the resulting solution was stirred
10 for 12 hours. The reaction mixture was diluted with methylene chloride (150 ml) and the resulting solution was washed with saturated sodium bicarbonate solution (2 X 40 ml), 10% citric acid solution (2 X 40 ml), and brine, then dried (magnesium sulfate) and concentrated to give the crude product. The analytically pure material was obtained via
15 preparative HPLC chromatography employing a Vydac C-18 column (4.5 X 150 mm, water-acetonitrile-1% trifluoroacetic acid 45 minute gradient). The homogeneous fractions containing product were pooled and concentrated. The residue was dissolved in methylene chloride containing trifluoroacetic acid (50%) at room temperature. After 2
20 hours, the volatiles were removed under reduced pressure to yield the title compound as a trifluoroacetate salt:

NMR: Consistent with structure and confirms presence of solvent;

HPLC: > 97% pure at 214 nm;

25 FAB MS: 615 ($M^+ + H$);

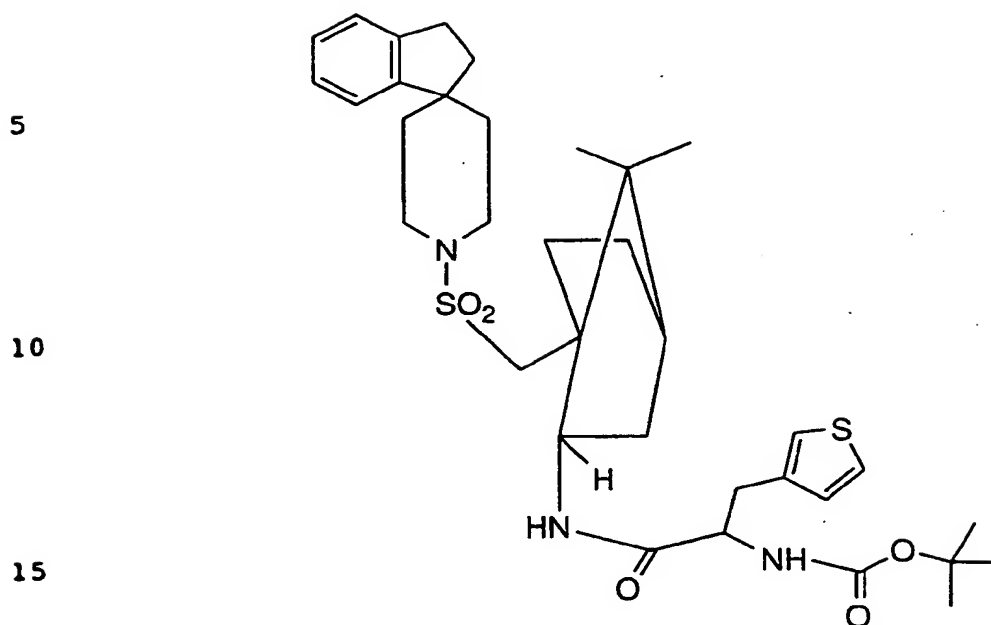
Elem Analysis calculated for $C_{34}H_{47}F_3N_4O_8S \cdot 0.3 H_2O \cdot 0.8 TFA$:

C, 51.59; H, 5.88; N, 6.74.

Found: C, 51.59; H, 5.89; N, 6.81.

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EXAMPLE 55

20 Endo-(1S)-1'-(((2-amino-7,7-dimethylbicyclo(2.2.1) hept-1-yl)methyl)sulfonyl)spiro(1H-indane-1,4'-piperidine)(216 mg, 0.53 mmole) and Na^a-tert-butyloxycarbonyl-D,L-(3-thienyl)alanine (160 mg, 0.59 mmole) were combined with 113 mg (0.59 mmole) of 1-ethyl-3-(3-dimethylaminopropyl) carbodiimide hydrochloride and 79 mg (0.59 mmole) of 1-hydroxybenzotriazole in 6 ml of dry methylene chloride at room temperature under nitrogen. The pH of the reaction mixture was

25 adjusted to 9 with triethylamine and the resulting solution was stirred for 12 hours. An additional 20 mg of tert-butyloxycarbonyl-D,L-(3-thienyl)alanine, 11 mg of 1-ethyl-3-(3-dimethylaminopropyl)-carbodiimide hydrochloride were added and stirring was continued for

30 6 hours more keeping the pH of the medium between 8 and 9. The reaction mixture was diluted with methylene chloride (150 ml) and the resulting solution was washed with saturated sodium bicarbonate solution (2 X 40 ml), 10% citric acid solution (2 X 40 ml), and brine, then dried (magnesium sulfate) and concentrated to give the crude product. The analytically pure material was obtained via flash column

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chromatography on silica gel (chloroform-methanol-concentrated ammonium hydroxide elution, 95:5:0.5 v/v) :

NMR: Consistent with structure and confirms presence of solvent;

5 HPLC: > 99% pure at 214 nm;

FAB MS: 656 ($M^+ + H$);

Elem Analysis calc'd for $C_{35}H_{49}N_3O_5S_2 \cdot 0.5 H_2O$:

C, 63.22; H, 7.58; N, 6.32.

Found: C, 63.26; H, 7.54; N, 6.10.

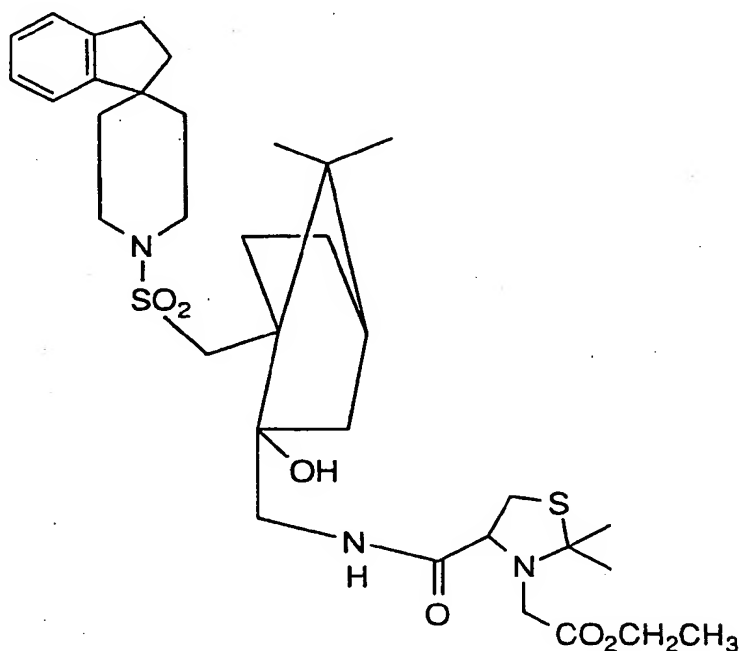
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EXAMPLE 56

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Endo(1S)-1'-(((2-amino-7,7-dimethylbicyclo(2.2.1) hept-1-yl)methyl)sulfonyl)spiro(1H-indane-1,4'-piperidine)(67 mg, 0.156 mmole) and N-ethyl-carboxymethyl-5,5-dimethyl-L-thiazolidine-4-carboxylic acid (57 mg, 0.23 mmole) were combined with 44 mg (0.23 mmole) of 1-ethyl-3-(3-dimethylaminopropyl) carbodiimide hydrochloride and 31 mg (0.23 mmole) of 1-hydroxybenzotriazole

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hydrate in 5 ml of dry methylene chloride at room temperature under nitrogen. The pH of the reaction mixture was adjusted to 8.5 with triethylamine and the resulting solution was stirred for 3 hours. The reaction mixture was diluted with methylene chloride (50 ml) and the resulting solution was washed with saturated sodium bicarbonate solution (2 X 40 ml), 10% citric acid solution (2 X 40 ml), and brine, then dried (magnesium sulfate) and concentrated to give the crude product. The analytically pure material was obtained via preparative thick layer chromatography (2 X 20 X 20 mm, pre-coated SiO₂ plates, hexane-ethyl acetate elution, 2:1 v/v). The analytical product was isolated in homogeneous form as a solid:

NMR: Consistent with structure and confirms presence of solvent;

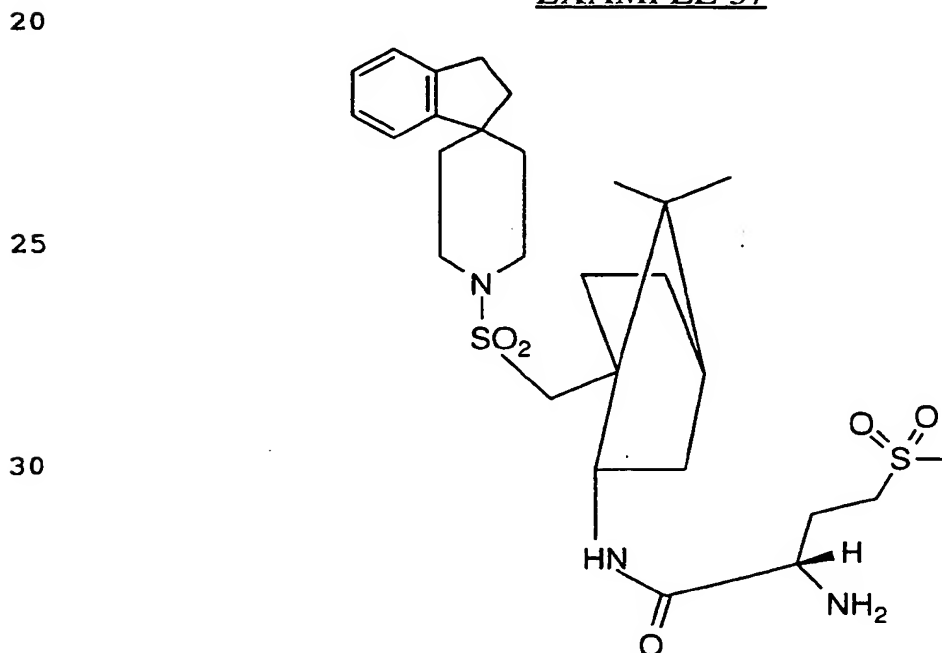
FAB MS: 660 ($M^+ + H$);

15 Elem. Analysis calc'd for $C_{34}H_{47}N_3O_6S_2 \cdot 0.85 H_2O \cdot 0.1 EtOAc$:

C, 60.40; H, 7.59; N, 6.14.

Found: C, 60.37; H, 7.36; N, 6.13.

EXAMPLE 57

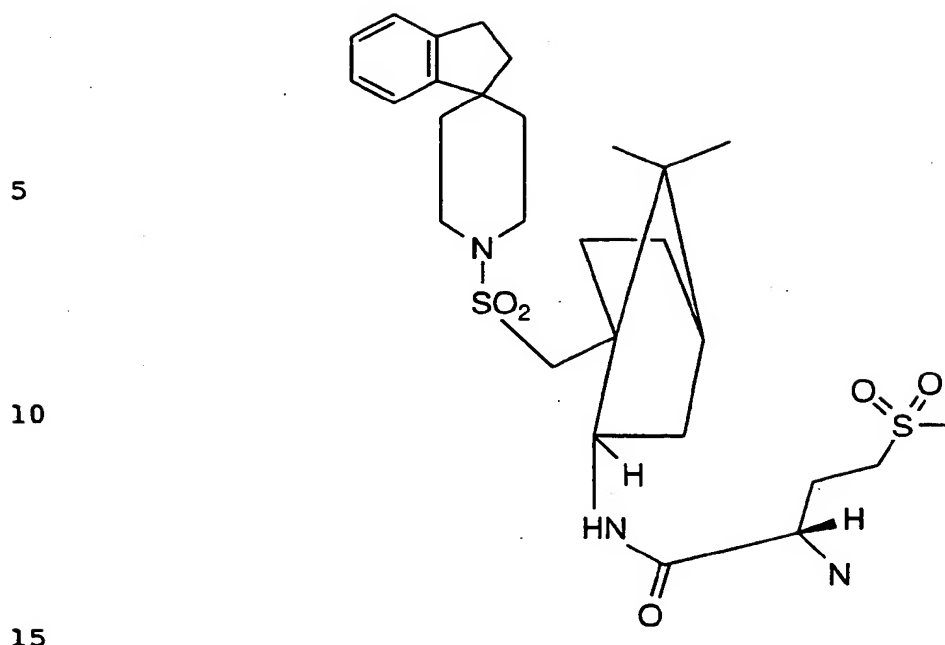


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To a stirred solution of 50 ml of dry N,N-dimethyl-formamide containing endo(1S)-1'-(((2-amino-7,7-dimethyl-bicyclo(2.2.1) hept-1-yl)methyl) sulfonyl)spiro(1H-indane-1,4'-
5 piperidine) (4.0g, 9.9 mmole) and Na-tert-butyloxycarbonyl-L-methioninesulfone (2.84 g, 11.9 mmole) was added 5.65 g (12.87 mmole) of benzotriazol-1-yloxytris(dimethylamino) phosphonium hexafluorophosphate. The pH of the reaction mixture was adjusted to 8.5 with diisopropylethylamine and the reaction mixture was stirred at
10 23°C for two hours. The reaction mixture was filtered and concentrated under reduced pressure to give a solid. This material was dissolved in ethyl acetate and this solution was washed in succession with saturated sodium bicarbonate solution (3 X 25 ml), 10% citric acid
15 solution (3 X 25 ml) and brine. The organic phase was dried (sodium sulfate) and concentrated to yield 2-tert-butyloxycarbonylamino-N-[1-[[[(2,3-dihydrospiro[1H-indene-1,4'-piperidin]-1'-yl)sulfonyl]methyl]-7,7-dimethylbicyclo[2.2.1]hept-2-yl]-4-(methylsulfonyl)-butanamide
20 which was purified by chromatography on silica gel (chloroform-methanol-concentrated ammonium hydroxide elution, 95:5:0.5 v/v) to yield a solid. This material was dissolved in 50 ml of ethyl acetate and the resulting solution was cooled to 0°C and treated with a continuous stream of hydrogen chloride gas for 15 minutes. The ice bath was removed, the reaction vessel was capped, and stirring was continued for
25 45 minutes more at room temperature. The solvent and excess hydrogen chloride were removed under reduced pressure to give 2-amino-N-[1-[[[(2,3-dihydrospiro[1H-indene-1,4'-piperidin]-1'-yl)-sulfonyl]methyl]-7,7-dimethyl-bicyclo[2.2.1]hept-2-yl]-4-(methylsulfonyl)butanamide hydrochloride as an off-white solid (6.5 g).

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2-amino-N-[1-[[[(2,3-dihydrospiro[1H-indene-1,4'-piperidin]-1'-yl)sulfonyl]methyl]-7,7-dimethylbicyclo[2.2.1]hept-2-yl]-4-(methylsulfonyl)-butanamide hydrochloride was chromatographed on silica gel (chloroform-methanol-concentrated ammonium hydroxide elution, 90:10:1 v/v) to afford a white solid which was dissolved in 15 ml of methanol containing 1% acetic acid. To this reaction mixture was added 3 ml of aqueous formaldehyde solution and 1.56 g (24.8 mmole) of sodium cyanoborohydride. The resulting reaction mixture was stirred at room temperature overnight. The reaction mixture was concentrated in vacuo and the residue was partitioned between ethyl acetate and saturated sodium bicarbonate solution. The phases were separated and the organic phase was washed with brine, dried (sodium sulfate), and concentrated under reduced pressure. The crude product was purified by chromatography on silica gel (chloroform-methanol-concentrated ammonium hydroxide elution, 95:5:0.5 v/v) to yield 2-dimethylamino-N-[1-[[[(2,3-dihydrospiro[1H-indene-1,4'-piperidin]-1'-yl)sulfonyl]methyl]-7,7-dimethylbicyclo[2.2.1]hept-2-yl]-4-(methylsulfonyl)butanamide:

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NMR: Consistent with structure and verifies presence of solvent;

HPLC: >98% pure at 214 nM;

FAB MS: 594($M^+ + H$);Elem. Analysis calc'd for $C_{30}H_{47}N_3O_5S_2 \cdot 0.1CHCl_3$:

5 C, 59.67; H, 7.84; N, 6.94.

Found: C, 59.90; H, 7.24; N, 6.93.

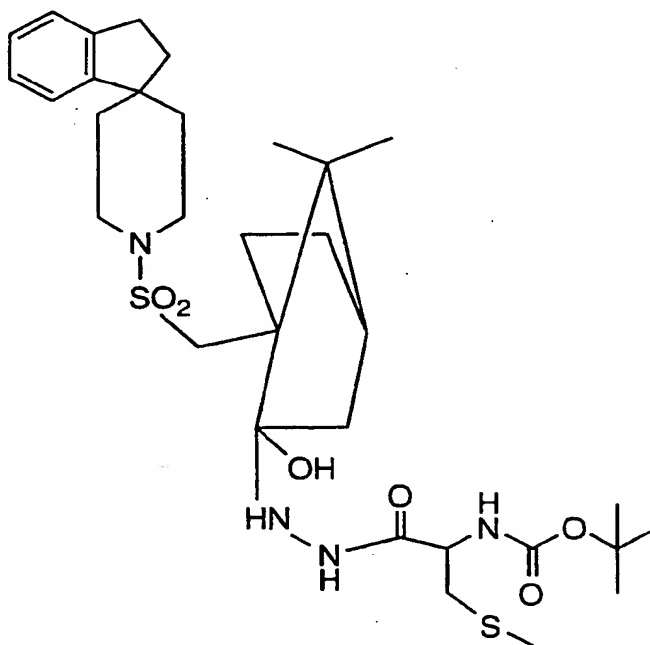
EXAMPLE 58

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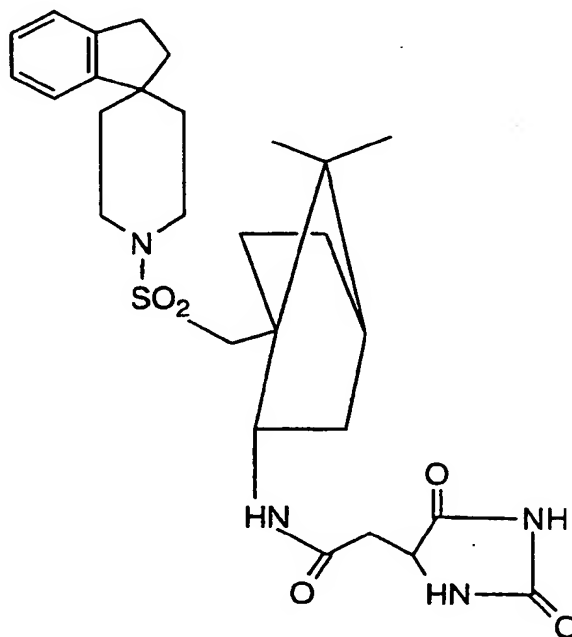
To a stirred solution of (1S)-1'-(((2-exo-hydroxy-2-endo-aminomethyl-7,7-dimethylbicyclo(2.2.1)hept-1-yl)methyl)sulfonyl)-spiro(1H-indene-1,4'-piperidine) (300 mg, 0.694 mmole) in 10 ml of dry, degassed N,N-dimethylformamide was added N^a -tert-butyloxy-carbonyl-S-methyl-L-cysteine (212 mg, 0.832 mmole) and 398 mg (0.902 mmole) of benzotriazol-1-yloxy tris(dimethylamino)-phosphonium hexafluorophosphate (BOP) at room temperature. The resulting reaction mixture was protected from moisture and the pH was adjusted to 8-9 with diisopropylethylamine. After 24 hours all volatile

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components were removed under reduced pressure and the residue was partitioned between ethyl acetate and sodium bicarbonate solution. The phases were separated and the organic phase was washed with saturated sodium bicarbonate solution (3 X 40 ml) and brine, then dried (magnesium sulfate) and concentrated. The crude product was chromatographed on silica gel (hexane-ethyl acetate elution, 3:1 v/v) to give the title compound:

NMR: Consistent with structure and verifies presence of solvent;
HPLC: >98% pure at 214 nM;
FAB MS: 650 ($M^+ + H$);
Elem. Analysis calc'd for $C_{33}H_{50}N_3O_6S_2$:
C, 61.07; H, 7.71; N, 6.47.
Found: C, 61.24; H, 7.98; N, 6.13.

EXAMPLE 59



To a stirred solution of (1S)-1'-(((2-exo-hydroxy-2-endo-aminomethyl-7,7-dimethylbicyclo(2.2.1)hept-1-yl)methyl)sulfonyl)-spiro(1H-indene-1,4'-piperidine) (125 mg, 0.311 mmole) in 7 ml of

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dry, degassed N,N-dimethylformamide was added S-hydantoinacetic acid (59 mg, 0.372 mmole) and 178 mg (0.404 mmole) of benzotriazol-1-yloxy tris(dimethylamino)phosphonium hexafluorophosphate (BOP) at room temperature. The resulting reaction mixture was protected from moisture and the pH was adjusted to 8-9 with diisopropyl-ethylamine. After 24 hours all volatile components were removed under reduced pressure and the residue was partitioned between ethyl acetate (100 ml) and sodium bicarbonate solution. The phases were separated and the organic phase was washed with saturated sodium bicarbonate solution (3 X 40 ml) and brine, then dried (magnesium sulfate) and concentrated. The crude product was initially flash chromatographed on silica gel (chloroform-methanol elution, 96:4, v/v) to give semi-pure material from which the title compound was obtained as a white solid after preparative thick layer chromatography on silica gel (chloroform-methanol-concentrated ammonium hydroxide elution, 96:4:0.4, v/v) and trituration with ether-petroleum ether:

NMR: Consistent with structure and verifies presence of solvent;

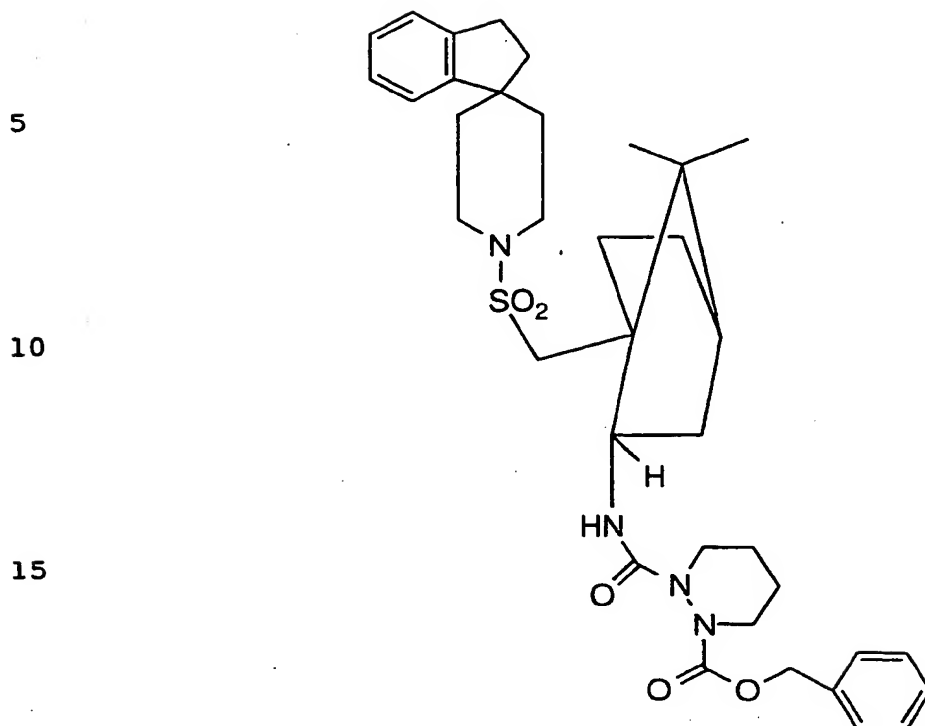
FAB MS: 543 ($M^+ + H$);

Elem. Analysis calculated for $C_{28}H_{48}N_4O_5S$

C, 61.96; H, 7.00; N, 10.32

Found: C, 61.70; H, 7.36; N, 10.09

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EXAMPLE 60

20 (1S)-1'-(((7,7-dimethyl-2-endo-(4-nitrophenyloxycarbonylamino)-
bicyclo-(2.2.1)-hept-1-yl)-methyl)-sulfonyl)spiro(1H-indan-1,4'-
piperidine

(1S)-1'-(((7,7-dimethyl-(2-endoamino)-bicyclo(2.2.1)-hept-
1-yl)-methyl)sulfonyl)spiro(1H-indene-1,4'-piperidine)[3.47mmol] and 4-
25 Nitrophenyl chloroformate [3.64mmol] were combined in THF. The
reaction mixture was treated with triethylamine [4.54 mmol] and
allowed to stir for 3 hours. The reaction mixture was concentrated to
dryness and the resulting residue was purified by a silica gel column,
while eluting with 1% ethylacetate in methylene chloride. The product
30 fractions were combined and concentrated to dryness in vacuo. (1S)-1'-
(((7,7-dimethyl-(4-nitrophenyloxycarbonyl-2-endoamino)-bicyclo-
(2.2.1)-hept-1-yl)-methyl)-sulfonyl)spiro(1H-indene-1,4'-piperidine was
obtained as a white solid from ether.

(1S)-1'-(((7,7-dimethyl-2-endo-(4-nitro-phenyloxy-
carbonylamino)-bicyclo-(2.2.1)-hept-1-yl)-methyl)sulfonyl)spiro(1H-

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indene-1,4'-piperidine)-[0.278mmol] and (benzyloxycarbonyl) piperazic acid [0.334mmol] were combined in DMF. The reaction mixture was treated with triethylamine [0.401mmol] and allowed to stir for 2 hours. The reaction mixture was concentrated to dryness and the resulting residue was dissolved in CH₂Cl₂. This solution was placed on a silica gel column and eluted with 5% methanol in CH₂Cl₂ and then with 96/4/0.4 of CH₂Cl₂/methanol/acetic acid. The product fractions were combined and evaporated to dryness. The title compound was obtained as a white solid from ether and was dried in vacuo overnight.

m.p.: 90-120°C

NMR: Consistent with structure

HPLC: >98% Pure

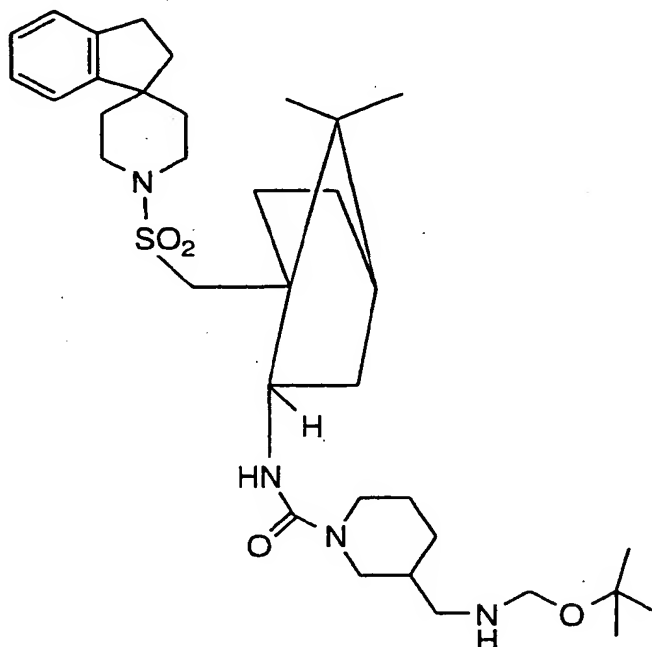
MS: M-->H⁺=693.6

Analysis calculated for C₃₇H₄₈N₄O₇S·0.20mol C₄H₁₀O·0.25mol H₂O

C, 63.74; H, 7.15; N, 7.87

Found: C, 63.78; H, 7.08; N, 7.81

EXAMPLE 61



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The procedure of Example 60, second paragraph was carried out using (1S)-1'-(((7,7-dimethyl-2-endo-(4-nitrophenyloxy-carbonylamino)-bicyclo-(2:2.1)-hept-1-yl)-methyl)sulfonyl)spiro(1H-indan-1,4'-piperidine)[0.193mmol], triethylamine [0.29mmol], and substituting 3-(t-butoxycarbonylamino-methyl)piperidine [0.212mmol] for (benzyloxycarbonyl) piperazic acid. Chromatographic elution was with 5% ether in CH₂Cl₂, 10% ether in CH₂Cl₂, and then 1% methanol in CH₂Cl₂. The title compound was obtained from ether and dried in vacuo, overnight.

m.p.: 95-105°C

NMR: Consistent with structure

HPLC: >97% Pure

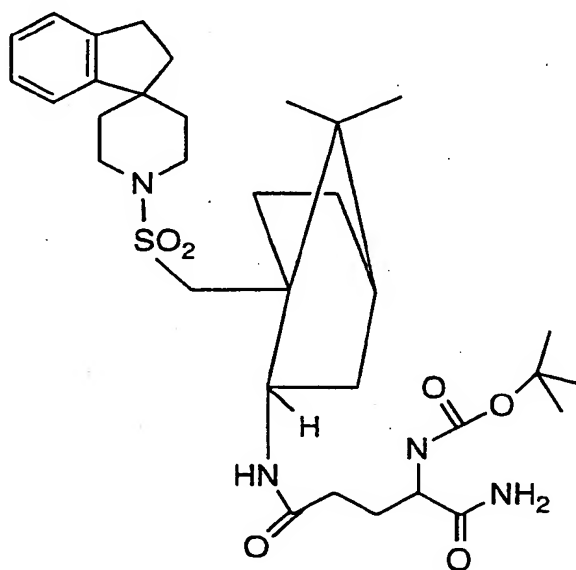
MS: M+H⁺=643.4

Analysis calculated for C₃₅H₅₄N₄O₅S·0.20 H₂O
C, 65.02; H, 8.48; N, 8.67
Found: C, 64.98; H, 8.43; N, 8.86

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EXAMPLE 62

Endo-(1S)-1'-(((2-(L-4(tert,butoxycarbonylamino)glutamamyl)amino-
7,7-dimethylbicyclo(2.2.1)hept-1-yl)-methyl)-sulfonyl)spiro-(1H)-
indan-1,4',piperidine



In an oven dried flask (50ml) under nitrogen was dissolved endo-(1S)-1'-(((2-amino-7,7-dimethyl-bicyclo(2.2.1)hept-1-yl)-methyl)-sulfonyl)spiro-(1H)-indan-1,4'-piperidine (50mg, 0.125mmol), L-4(tert-butoxycarbonyl)glutamamic acid (34mg, 0.14mmol), 1-ethyl-3-(3-dimethylaminopropyl)carbodiimide hydrochloride (30mg, 0.15mmol), and 1-hydroxybenz-triazole hydrate (20mg 0.15mmol) in dimethyl formamide (1ml). Triethylamine (50ml) was added and a white solid separated. After stirring for 1 hour, the solvent was removed under reduced pressure. The residue was dissolved in ether:methylene chloride (3:1). The cloudy solution was washed with sodium bicarbonate (sat., aqueous), water, potassium hydrogen sulfate (10%, aqueous) and brine. After drying over sodium sulfate, the organic material was filtered and concentrated. Silica "flash" chromatography using methylene chloride methanol (9:1) gave the product which was isolated as an oil upon evaporation of the solvents. Hexane:ether

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addition and removal under reduced pressure produced the title compound as a white foam.

HPLC: >99%

5 MS: $M+H^+=631.3$

NMR consistent with structure

Analysis calculated for $C_{33}H_{50}N_4O_6S \cdot 0.5 DMF \cdot 0.5 H_2O$

C, 61.26; H, 8.12; N, 9.32

Found: C, 61.27; H, 8.05; N, 9.31

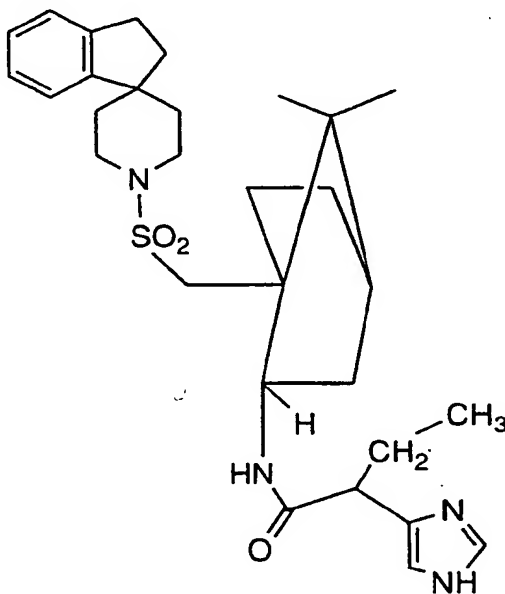
10

EXAMPLE 63

Endo-(1S)-1'-(((2-(4(imidazole-2-ethylacetyl)amino-7,7-dimethyl-
bicyclo(2.2.1)hept-1-yl)-methyl)spiro-(1H)-indan-(1,4'),piperidine
15 hydrochloride

20

25



30

Step 1: Endo-(1S)-1'-(((2-4(3-methylbenzyloxy)imidazole)-2-
[ethyl acetyl)amino-7,7-dimethylbicyclo- (2.2.1)hept-1-
yl)-methyl)-sulfonyl)spiro(1H)-indan-(1,4')-piperidine

Into an over dried flask (50ml) under nitrogen was placed dimethylformamide (4ml). Endo(1S)-1'-((2-amino-7,7-dimethyl-

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bicyclo(2.2.1)hept-1-yl)-methyl)sulfonyl)spiro(1H)-indan-(1,4')-piperidine (300mg, 0.74mmol); 4(3-methylbenzyloxy)imidazole-2-ethylacetic acid (219mg, 0.8mmol), 1-ethyl-3-methyl-(3-dimethyl-aminopropyl)carbodiimidehydrochloride-(153mg, 0.8mmol) and 1-hydroxybenztriazolehydrate-(108mg, 0.83mmol) were added and the mixture was stirred until solution was achieved. Triethylamine (400ml) was added to make the solution basic (pH 9) and a solid separated. After stirring overnight room temperature, the solvent was removed under reduced pressure. The resulting gum was dissolved in methylenechloride:ether (1:3) and the cloudy solution was extracted with sodium bicarbonate (sat., aqueous) and brine. After drying the organic layers over sodium sulfate, the solution was filtered and was concentrated. The product was purified by silica gel "flash" chromatography using methylene chloride, methanol, ammonium hydroxide (9:1:1) as solvents. The product fractions were concentrated to give the title compound as white foam.

HPLC: >95% (42% + 53%)

MS: $M+H^+=659.3$

NMR ($CDCl_3$) consistent with structure

Analysis calculated for $C_{38}H_{50}N_4O_4S \cdot 0.65H_2O$
C, 68.05; H, 7.71; N, 8.36

Found: C, 68.03; H, 7.87; N, 8.60

Nitrogen was bubbled into a solution of Endo(1S)-1'-(((2-4-(3-methylbenzyloxyimidazole)-2-ethylacetyl-amino-7,7-dimethyl-bicyclo(2.2.1)hept-1-yl)-methyl)-sulfonyl)spiro-(1H)-indan-(1m4')piperidine (50mg, 0.076mmol) in absolute ethanol (20ml)-acetic acid (5ml). After 5 minutes, 10%Pd/C(50mg) was added and the mixture was hydrogenated at 55psi overnight. The catalyst was removed by filtration and the solvents were concentrated to dryness under reduced pressure. The residue was purified by silica gel "flash" chromatography using methylenechloride, methanol, ammonium hydroxide (9:1:1) as solvent. The product fractions were collected and concentrated. The gum was redissolved in methylene chloride and was

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filtered through a sintered glass funnel. After the solution was concentrated, the residue was dissolved in ethyl acetate (5ml). The solution was cooled to 0° and it was saturated with hydrogen chloride gas (bubbling 5 minutes). The solvent was removed under reduced pressure and ether was added and was removed to give the title compound as a white solid.

HPLC: >90% (42% + 45%)

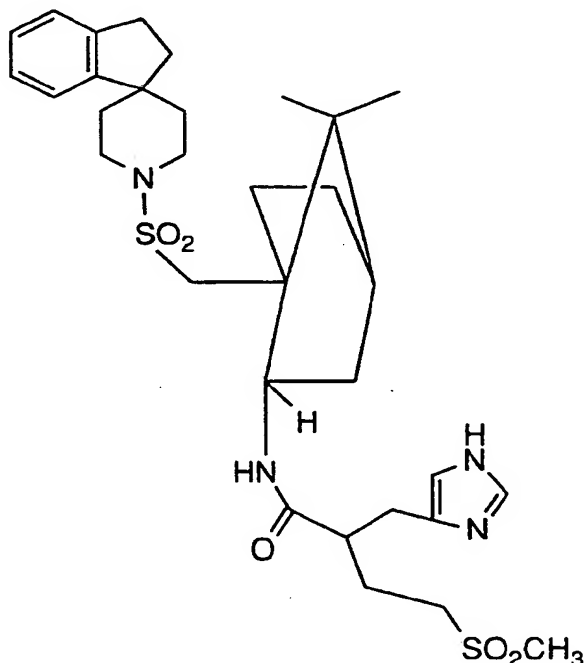
MS: $M+H^+ = 539.2$ (freebase)

10 NMR ($CDCl_3$) consistent with structure

Analysis calculated for $C_{30}H_{42}N_4O_3S \cdot HCl \cdot 0.25 \text{ ether} \cdot 130H_2O$
C, 60.33; H, 7.86; N-9.08

Found: C, 60.33; H, 7.48; N-9.04

15 EXAMPLE 64



To a stirred solution of the product of Example A (500 mg, 1.24 mmol) in DMF (10 mL) was added the HCl salt of 2-(1-benzyloxy-methylimidazoly-5-yl)-4-methylsulfonylbutanoic acid (506 mg; 1.30

- 145 -

mmol), DIEA (0.70 mL; 4.0 mmol), and BOP (600 mg; 1.35 mmol). After being stirred at ambient temperature for 14 h, the solvent was removed under reduced pressure. The residue was dissolved in EtOAc (75 mL) and washed with aqueous NaHCO₃ (3 x 50 mL). The organic phase was dried (MgSO₄), filtered, and the solvent was removed under reduced pressure. The benzyloxymethyl protecting group was removed by dissolving the residue in a 4:1 solution of EtOH-HOAc (10 mL) and hydrogenating over palladium black (75 mg) under 1 atm of hydrogen for 24 h. The catalyst was removed by filtration through Celite and the filtrate solvents were removed under reduced pressure. The residue was purified by pressurized silica gel column chromatography using a 50:50:7 by volume mixture of CHCl₃, EtOAc, and 4% NH₄OH-MeOH as eluant. Two diastereomers were obtained and each was lyophilized from water containing 1% TFA. The title compound is the lower R_f isomer.

Higher R_f Isomer:

Analysis calculated for (C₃₁H₄₄N₄O₅S₂)·1.0 TFA·1.1 H₂O
 C, 52.45; H, 6.24; N, 7.37
20 Found: C, 52.69; H, 6.12; N, 7.32

TLC: R_f 0.33 (50:50:7 CHCl₃:EtOAc:4%NH₄OH-MeOH)

HPLC (method A): retention time 8.96 min

FAB MS: m/z 617 (M⁺ + H)

25 ¹H NMR (300 MHz, CDCl₃): free base: d 7.70 (s, 1H), 7.55 (br d, 1H), 7.15-7.25 (m, 4H), 7.00 (s, 1H), 4.35 (m, 1H), 2.90 (s, 3H), 1.00 (s, 3H), 0.98 (s, 3H)

Lower R_f Isomer:

30 Analysis calculated for (C₃₁H₄₄N₄O₅S₂)·1.0 TFA·1.3 H₂O
 C, 52.55; H 6.36; N 7.43
Found: C, 52.89; H 6.13; N 7.43

TLC: R_f 0.28 (50:50:7 CHCl₃:EtOAc:4%NH₄OH-MeOH)

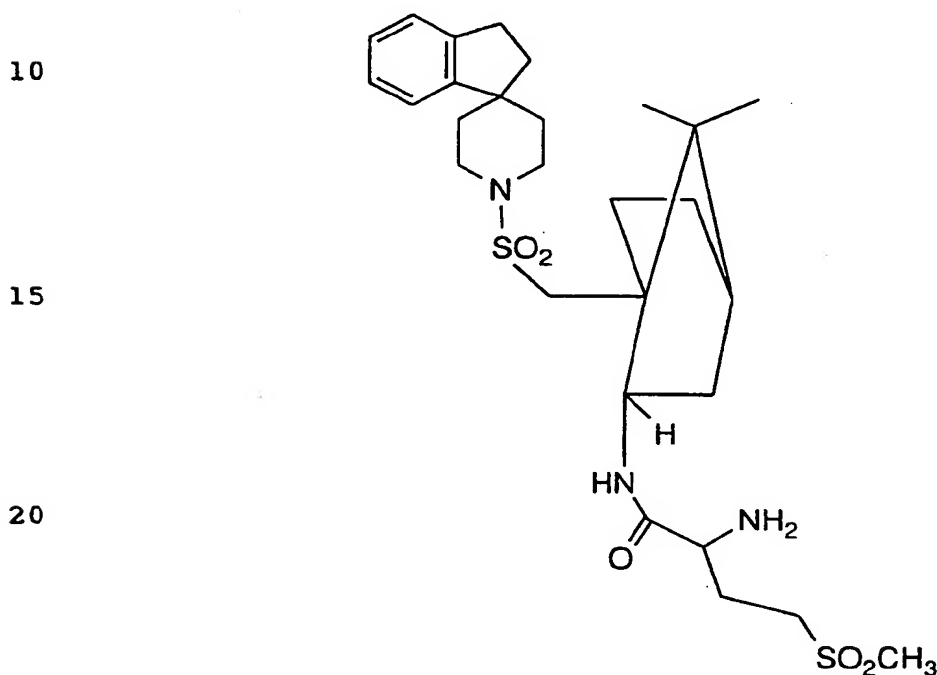
HPLC (method A): retention time 9.15 min

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FAB MS: m/z 617 ($M^+ + H$)

5 ¹H NMR (300 MHz, CDCl₃): free base: d 7.72 (s, 1H), 7.34 (br d, 1H), 7.15-7.25 (m, 4H), 6.98 (s, 1H), 4.35 (m, 1H), 2.90 (s, 3H), 1.00 (s, 3H), 0.96 (s, 3H)

EXAMPLE 65



To a 0°C stirred solution of the product of Example A (1.10 g; 2.74 mmol) in CHCl₃ (100 mL) was added DIEA (0.75 mL; 4.3 mmol) and benzyl chloroformate (0.51 g; 3.0 mmol). The solution was stirred at 0°C for 1 h and then at ambient temperature for 14 h. The reaction mixture was concentrated under reduced pressure and the residue was dissolved in 25 mL of a solution of 10:1 MeOH-NH₄OH. The mixture was concentrated under reduced pressure, the residue was dissolved in CHCl₃ (100 mL) and washed with 5% aqueous HCl (2 x 50 mL) and aqueous NaHCO₃ (100 mL). The organic phase was dried (MgSO₄), filtered, and the solvent was removed under reduced pressure. The residue was purified by pressurized silica gel

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column chromatography using 1:4 EtOAc-hexanes as eluant. The benzyl urethane was obtained as a white foam.

TLC: R_f 0.40 (1:3 EtOAc:hexanes)

5 HPLC (method A): retention time 12.25 min

FAB MS: m/z 537 ($M^+ + H$)

To a 0°C stirred solution of the benzyl urethane (1.25 g; 2.33 mmol) in DMF (20 mL) was added iodomethane (0.435 mL; 7.00 mmol) and sodium hydride (0.140 mg of a 60% dispersion in mineral oil; 3.50 mmol). The solution was stirred at 0°C for 1 h and then at ambient temperature for 18 h. The reaction mixture was treated with HOAc (1 mL) and the solvents were removed under reduced pressure. The residue was dissolved in EtOAc (100 mL) and washed with aqueous NaHCO₃ (2 x 50 mL). The organic phase was dried (MgSO₄), filtered, and the solvent was removed under reduced pressure. The residue was purified by pressurized silica gel column chromatography using 1:5 EtOAc-hexanes as eluant. The N-methyl benzyl urethane was obtained as a white foam.

15 TLC: R_f 0.34 (1:4 EtOAc:hexanes)

20 HPLC (method A): retention time 12.71 min

FAB MS: m/z 551 ($M^+ + H$)

To a stirred, argon purged solution of the N-methyl benzyl urethane (1.00 g; 1.82 mmol) in 96:4 MeOH-HCO₂H (25 mL) was added palladium black (0.37 g). The reaction mixture was stirred for 16 h at ambient temperature. The catalyst was removed by filtration through Celite, and the filtrate solvents were removed under reduced pressure. The residue was purified by pressurized silica gel column chromatography using 95:5:0.5 CHCl₃:MeOH:NH₄OH as eluant. The N-methyl endo-amine product was obtained as a white foam.

25 30 TLC: R_f 0.35 (92:8:0.8 CHCl₃:MeOH:NH₄OH)

HPLC (method A): retention time 7.88 min

FAB MS: m/z 417 ($M^+ + H$)

To a stirred solution of the N-methyl endo-amine (0.650 g; 1.56 mmol) in CHCl₃ (50 mL) was added the acid fluoride of Na-Boc-

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L-methionine sulfone (510 mg; 1.80 mmol) and DIEA (0.35 mL; 2.0 mmol). The mixture was stirred at ambient temperature for 48 h, and then extracted with 10% aqueous citric acid solution (2 x 30 mL), water (30 mL), and aqueous NaHCO₃ (2 x 30 mL). The organic phase was
5 dried (MgSO₄), filtered, and the solvent was removed under reduced pressure. The residue was dissolved in CH₂Cl₂ (10 mL), and to the solution was added TFA (6 mL). The mixture was stirred at ambient temperature for 1.5 h. The solvents were removed under reduced pressure and the residue was purified by preparative reverse phase
10 HPLC using a water-acetonitrile gradient containing 0.1% TFA. The TFA salt of the title compound was obtained as a lyophilized powder.

Analysis calculated for (C₂₉H₄₅N₃O₅S₂)·0.4 TFA·0.5 EtOAc
 C 57.04 H 7.55 N 6.28
15 Found: C 57.04 H 7.44 N 6.28
TLC: R_f 0.18 (95:5:0.5 CHCl₃:MeOH:NH₄OH)
HPLC (method A): retention time 9.80 min
FAB MS: m/z 580 (M⁺ + H)
1H NMR (300 MHz, CDCl₃): δ 7.15-7.25 (m, 4H), 5.20 (m, 2H), 3.17
20 (s, 3H), 2.92 (s, 3H), 1.06 (s, 3H), 0.96 (s, 3H)

EXAMPLE 66

To a stirred solution of endo-(1S)-1'(((2-amino-7,7-
25 dimethylbicyclo(2.2.1)-hept-1-yl)-methyl)-sulfonyl)spiro(1H-indan-1,4'-piperidine (94 mg; 0.17 mmol) in ethanol (20 mL) was added N-(3-bromopropyl)-phthalimide (69 mg; 0.255 mmol) followed by diisopropylethyl amine (0.044 mL; 0.255 mmol). The temperature was then increased to 50°C. After approximately 18 hr the solution was
30 cooled then concentrated under reduced pressure. The residue was dissolved in methylene chloride (150 mL), washed with 1M HCl (2 x 150 mL) then dried over sodium sulfate and concentrated. Purification by flash chromatography (5% methanol in methylene chloride) afforded the title compound (45 mg; 40%) as a white solid.

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Analysis calculated for $(C_{39}H_{50}N_4O_6S) \cdot 0.10 H_2O \cdot 0.15 CH_2Cl_2$
C, 65.54; H, 7.10; N, 7.81

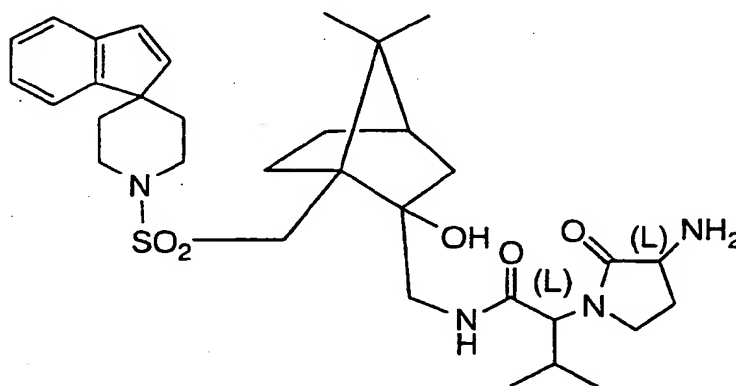
Found: C, 65.52; H, 7.09; N, 7.71

HPLC: (Vydac C18 Column; gradient from 95/5 to 100 H₂O/CH₃CN
with 0.1% TFA. 15 min. gradient, flow rate = 1.5 ml/min.)
R_t = 13.81 min. Purity = 100%

¹HNMR: Consistent with structure

FABMS: m/z = 703 (M⁺ + H)

EXAMPLE 67



Valine methyl ester (2.5g, 14.9 mmol), t-BOC-methionine (3.73 g, 14.9 mmol), HBT (2.01 g, 14.9 mmol) and EDC (2.33g, 14.91 mmol) were suspended in methylene chloride (60ml). The pH of the reaction was adjusted using E. Merck strips to about 9 with Et₃N. After stirring overnight at ambient temperature, the reaction was evaporated and the residue was dissolved in ethyl acetate (60ml). The ethyl acetate solution was extracted three times with 5M citric acid (20 ml), three times with 1M sodium bicarbonate (20 ml), one time with water and one time with saturated sodium chloride (20ml). The ethyl acetate solution was then dried over anhydrous sodium sulfate, filtered and evaporated to dryness.

The residue was dissolved in methyl iodide (25ml) and stirred overnight, and the resulting mixture was evaporated to dryness. The resulting methyl sulfonium salt (4.72mmol) was dissolved in a 1:1

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5 mixture of DMF and methylene chloride (150ml). After cooling to zero degrees in a saltwater/ice bath, sodium hydride (60% in mineral oil: 0.57g, 9.44mmol) was added. After stirring for 3hr, the reaction was treated with glacial acetic acid (1 ml) followed by water (1 ml). The
10 mixture was stirred for 15min. at ambient temperature, then evaporated. The crude product was dissolved in water (150 ml) and neutralized with aqueous sodium bicarbonate. The mineral oil and neutral by-products were removed by extracting three times with methylene chloride (50 ml). The aqueous layer was then acidified with
15 citric acid and extracted three times with methylene chloride (50ml). The combined methylene chloride layers were dried over sodium sulfate, filtered and evaporated. Purification of the crude product was carried out by preparative HPLC using a Waters C-18 column in a SepTech ST/Lab 800C instrument with a water/acetonitrile gradient increasing from 10% to ca. 60% acetonitrile.

The product so obtained (60 mg, 0.20 mmol) was combined with (1S)-1'-(((7,7-dimethyl-(2-endo-aminomethyl-2-exo-hydroxy)-bicyclo-(2.2.1)-hept-1-yl)-methyl)sulfonyl)-spiro-(1H-indene-1,4'-piperidine) (86 mg, 0.20 mmol), HBT (27 mg, 0.20 mmol) and EDC
20 (38 mg, 0.20 mmol) in methylene chloride (10 ml). The pH of the mixture was adjusted to ca. 9 with triethylamine. After stirring overnight, the reaction was evaporated and the residue was dissolved in ethyl acetate (25ml). The ethyl acetate solution was extracted three
25 times with 5M citric acid (2ml), three times with 1M sodium bicarbonate (2ml), one time with water and one time with saturated sodium chloride (2ml). The ethyl acetate solution was then dried over anhydrous sodium sulfate, filtered and evaporated to dryness. The product was dissolved in a 40% solution of trifluoroacetic acid in methylene chloride (3 ml) and stirred for 1hr at ambient temperature.
30 The solvent was then evaporated, and the residue was dissolved in methanol and purified by preparative HPLC using the conditions described.

NMR: Consistent with structure

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FAB MS: 613 ($M^+ + H$)

HPLC: >99% pure at 214 nM

Analysis calc'd for $C_{33}H_{47}N_4O_5 \cdot 2.0 C_2HF_3O_2 \cdot 1.4H_2O$:

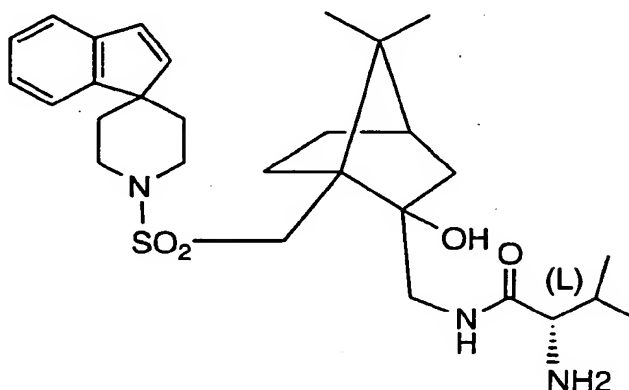
Calc'd: C, 51.31; H, 6.15; N, 6.47

5 Found: C, 51.31; H, 6.00; N, 6.66.

EXAMPLE 68

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To a solution of (1S)-1'-(((7,7-dimethyl-(2-endo-amino-methyl-2-exo-hydroxy)-bicyclo-(2.2.1)-hept-1-yl)-methyl)sulfonyl)-spiro(1H-indene-1,4''-piperdine (100 mg; 0.23 mmol) in DMF was added t-boc-L-valine (60 mg; 0.28 mmol), 1-hydroxybenzotriazole (37 mg; 0.28 mmol), and 1-(3-dimethylaminopropyl)-3-ethylcarbodiimide (53 mg; 0.28 mmol). The pH was adjusted to 9 with triethylamine (96 μ L; 0.69 mmol). After stirring for 1.5 hrs., the solution was concentrated to dryness and treated with 5% citric acid solution. This water layer was then basified with saturated sodium bicarbonate and extracted 3 times with ethyl acetate. The organics were combined and dried over sodium sulfate, filtered, and concentrated to yield a white oily foam. This white foam was dissolved in ethyl acetate, cooled to 0°C and treated with saturated solution of HCl in ethyl acetate. The reaction mixture was stirred for 45 min., purged with N_2 for 30 min., and then concentrated to dryness. The resulting solid was partitioned between ethyl acetate and saturated sodium bicarbonate. The aqueous

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layer was extracted 3 times with ethyl acetate, and the combined organic fractions were dried over sodium sulfate, filtered, and concentrated in vacuo. The residue was purified by flash chromatography (eluted with 98/2/0.2 of methylene chloride/methanol/ammonium hydroxide) to yield the title compound as a white foam.

m.p.: not available

NMR: consistent with structure

HPLC > 97% pure

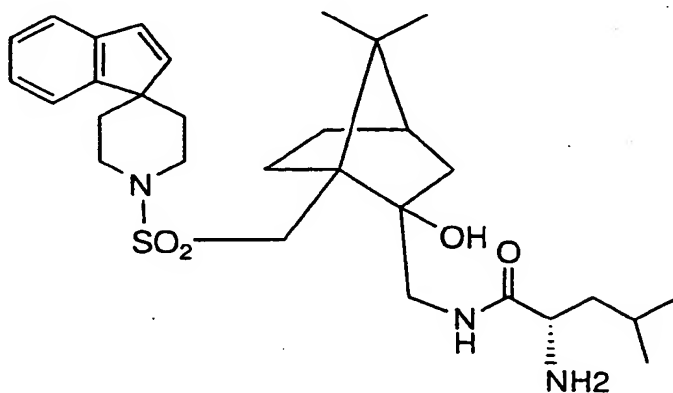
MS: MH-530.3 (FAB)]

CHN Analysis calculated for C₂₉H₄₃N₃O₄S

C, 65.75; H, 8.18; N, 7.93

Found: C, 65.75; H, 8.18; N, 7.93

EXAMPLE 69



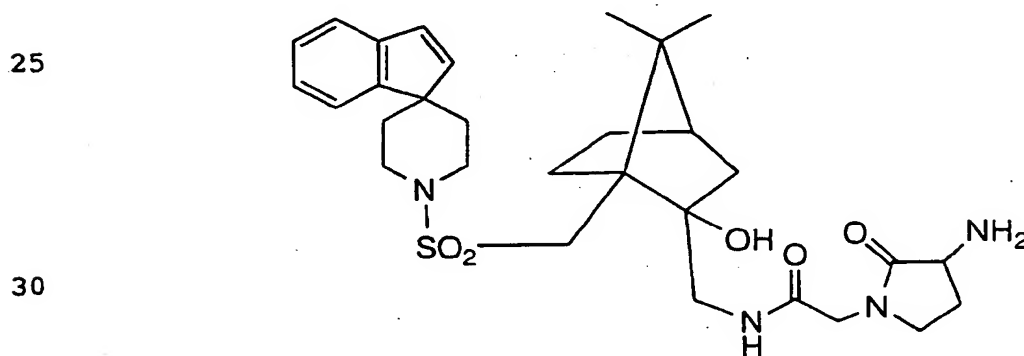
To a solution of (1S)-1'-((((7,7-dimethyl-(2-endo-amino-methyl-2-exo-hydroxy)-bicyclo-(2.2.1)-hept-1-yl)-methyl)sulfonyl)-spiro(1H-indene-1,4''-piperidine) 51 mg; 0.12 mmol) in DMF was added t-boc-L-leucine (36 mg; 0.14 mmol), 1-hydroxybenzotriazole (19 mg; 0.14 mmol), and 1-(3-dimethylaminopropyl)-3-ethylcarbodiimide (28 mg; 0.14 mmol). The pH was adjusted to 9 with triethylamine (50 µL, 0.36 mmol). After stirring for 18 hrs., the solution was concentrated to dryness and treated with 5% citric acid solution. The water layer was then basified with saturated sodium bicarbonate and extracted 3 times

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with ethyl acetate. The organics were combined and dried over sodium sulfate, filtered, and concentrated to yield a yellow oil. This yellow oil was dissolved in ethyl acetate, cooled to 0°C and treated with a saturated solution of HCl in ethyl acetate. The reaction mixture was stirred for 45 min., purged with N₂ for 30 min., and then concentrated to dryness. The resulting solid was partitioned between ethyl acetate and saturated sodium bicarbonate the aqueous layer was extracted 3 times with ethyl acetate and the combined organic fractions were dried over sodium sulfate, filtered, and concentrated in vacuo. The residue purified by flash chromatography (eluted with 98/2/0.2 of methylene chloride/methanol/ammonium hydroxide) to yield the title compound as a white foam.

m.p.: 88 - 110° C
NMR: consistent with structure
HPLC: > 98% pure
MS: MH-544.3 (FAB)
CHN Analysis calculated for C₃₀H₄₅N₃O₄S.0.35H₂O:
C, 65.50; H, 8.37; N, 7.64
Found: C, 65.48; H, 8.39; N, 7.60

EXAMPLE 70



To a solution of (1S)-1'-(((7,7-dimethyl-(2-endo-amino-methyl-2-exo-hydroxy)-bicyclo-(2.2.1)-hept-1-yl)-methyl)sulfonyl)-spiro(1H-indene-1,4''-piperidine) (72 mg; 0.17 mmol) in DMF was

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added 2-(3-amino-2-oxopyrrolidin-1-yl)acetic acid (52 mg; 0.20 mmol),
1-hydroxybenzotriazole (27 mg; 0.20 mmol), and 1-(3-dimethyl-
aminopropyl)-3-ethylcarbodiimide (38 mg; 0.20 mmol). The pH was
adjusted to 9 with triethylamine (70 μ L; 0.50 mmol). After stirring for
18 hrs., the solution was concentrated to dryness and treated with 5%
citric acid solution. The water layer was then basified with saturated
sodium bicarbonate and extracted 3 times with ethyl acetate. The
organics were combined and dried over sodium sulfate, filtered, and
concentrated to yield a yellow oil which was purified by flash
chromatography (eluted with 98/2/0.2 of methylene chloride/methanol/
ammonium hydroxide). The product was dissolved in ethyl acetate,
cooled to 0°C, and treated with a saturated solution of HCl in ethyl
acetate. The reaction mixture was concentrated to dryness. The
resulting solid was partitioned between ethyl acetate and saturated
sodium bicarbonate. The aqueous layer was extracted 3 times with ethyl
acetate and the organic fractions were combined, and dried over sodium
sulfate, filtered and concentrated in vacuo. The residue was purified by
flash chromatography (eluted with 97/3/0.3 of methylene
chloride/methanol/ammonium hydroxide) to yield the title compound as
a white foam.

m.p.: 115 - 155°C

NMR: consistent with structure

HPLC: > 98% pure

MS: M+H-571 (FAB)

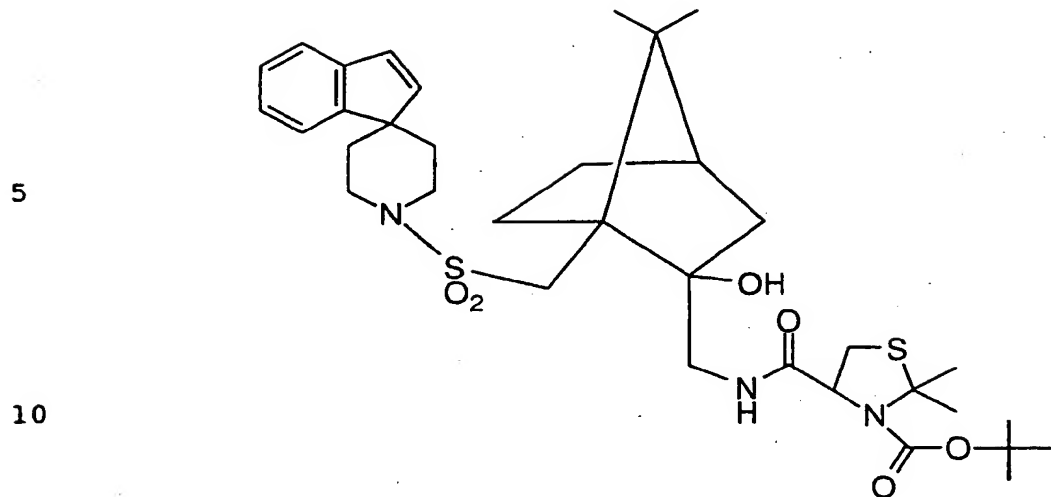
CHN Analysis calculated for C₃₀H₄₂N₄O₅S.0.85H₂O•0.25
C₄H₁₀O:

C, 61.58; H, 7.70; N, 9.27

Found: C, 61.56, H, 7.44; N, 9.23

EXAMPLE 71

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Endo (1S)-1'(((2-aminomethyl-7,7-dimethylbicyclo-(2.2.1)hept-1-yl)methyl)sulfonyl)spiro(indene-1,4'-piperidine) (337 mg, 0.78 mmole) and N-isobutyl-oxycarbonyl-5,5-dimethyl-L-thiazolidine-4-carboxylic acid (230 mg, 0.90 mmole) were combined with 438 mg (0.99 mmole) of benzotriazol-1-yloxytris(dimethylamino)phosphonium hexafluorophosphate in 5 ml of dry dimethyl formamide at room temperature with protection from moisture (calcium sulfate drying tube). The pH of mixture was adjusted to 8.5 with diisopropyl-ethylamine. The resulting solution was allowed to stir at room temperature for two hours. The dimethylformamide was then removed under reduced pressure, and the residue taken up in 150 ml of ethyl acetate and washed with saturated sodium bicarbonate (2 x 25 ml) and brine (1 x 25 ml). The ethyl acetate was dried over sodium sulfate, filtered, and concentrated to give 941 mg of an oil. The analytically pure material was obtained via chromatography on precoated silica gel plates (1.5 mm x 20 x 20 cm) developed with ethyl acetate in hexane (35:65). The product was obtained as an oil.

NMR: consistent with structure

FAB MS: $M^+ + H = 574$ (Compound minus t-BOC)

Analysis calculated for $C_{35}H_{51}N_3O_6S_2 \cdot 1.3 CHCl_3$

C, 52.58; H, 5.35; N, 5.07

Found: C, 52.62; H, 6.40; N, 4.99

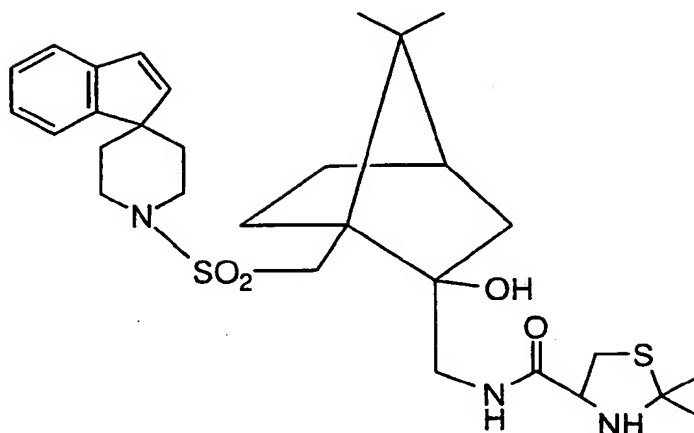
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EXAMPLE 72

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The product of the preceding Example 71 was dissolved in ethyl acetate, and the solution was cooled to 0°C. HCl (g) was bubbled into the solution for three minutes, and then let stand at 0°C for 30 minutes. The ethyl acetate was removed under vacuum and the residue evaporated twice from ethyl acetate. The residue was chromatographed on precoated silica gel plates 6.5 mm x 20 cm x 20 cm) using chloroform-methanol-ammonium hydroxide (97-3-0.3/v-v-v) to develop the plates. The product was obtained as an amorphous solid.

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m.p.: 126 - 129°C

NMR: consistent with structure

FAB MS: M⁺+H = 574.3

Analysis calculated for C₃₀H₄₃N₃O₄S₂•0.15 CHCl₃

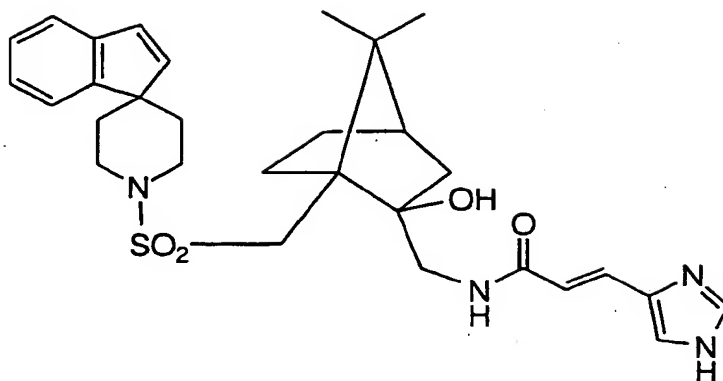
C, 61.19; H, 7.35; N, 7.10

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Found: C, 61.10; H, 7.33; N, 7.12

EXAMPLE 73

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To a solution of (1S)-1'-(((7,7-dimethyl-(2-endo-amino-methyl-2-exo-hydroxy)-bicyclo-(2.2.1)-hept-1-yl)-methyl)sulfonyl)-spiro(1H-indene-1,4-piperidine) (108 mg; 0.25 mmol) in degassed DMF was added 4-imidazoleacrylic acid (41.44 mg; 0.30 mmol) and benzotriazol-1-yloxy-tris(dimethylamino)phosphonium hexafluorophosphate (132.69 mg; 0.30 mmol). The pH of the reaction mixture was adjusted to 9 with diisopropylethylamine. After stirring for 14 hr, the reaction mixture was concentrated to dryness. The resulting solid was dissolved in methanol and then purified by reverse phase preparative HPLC utilizing a Water C-18 column (45 minute gradient, 5% to 70% acetonitrile/water containing 0.1% trifluoroacetic acid, 13.5 ml/min flow rate). The product containing fractions were combined and lyophilized to give an amorphous white solid.

NMR: consistent with structure;

HPLC: > 97% pure (254 nM)

FAB MS: M+H+ thioglycerol matrix = 659

CHN Analysis calculated for C₃₀H₃₈N₄O₄S•1.6CF₃CO₂H

Calc'd: C, 54.39; H, 5.44; N, 7.64.

Found: C, 54.50; H, 5.20; N, 7.53.

In addition to those compounds specifically exemplified above, additional compounds of the present invention are set forth in tabular form below. These compounds are synthesized by use of the synthetic routes and methods described in the above Schemes and

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Examples and variations thereof well known to those of ordinary skill in the art, and not requiring undue experimentation. All variables listed in the Tables below are with reference to the following generic structure:

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TABLES

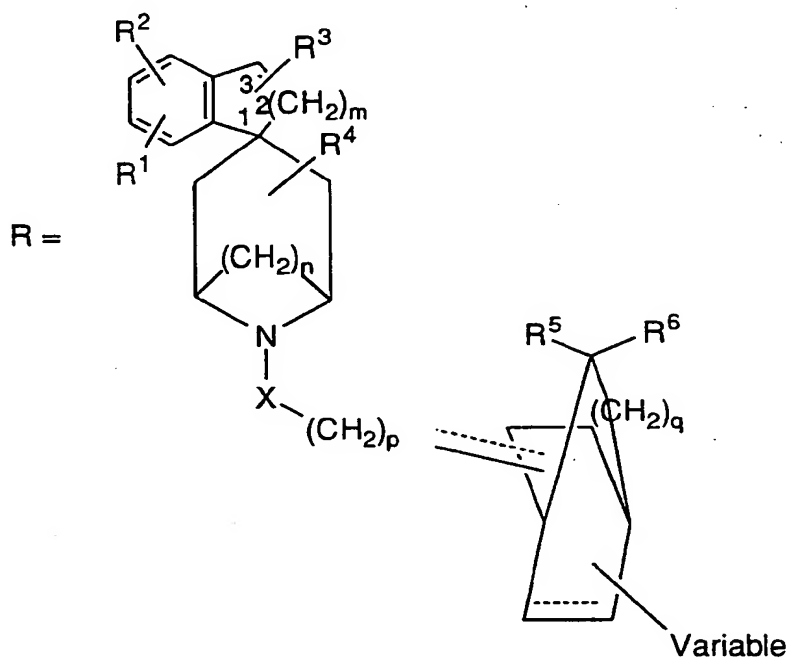
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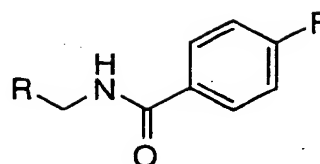
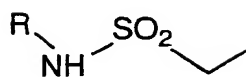
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TABLE 1

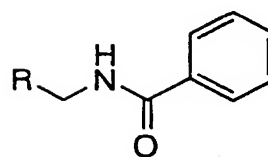
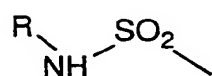
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Variable =

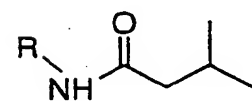
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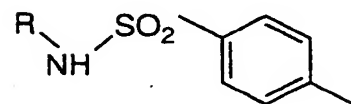
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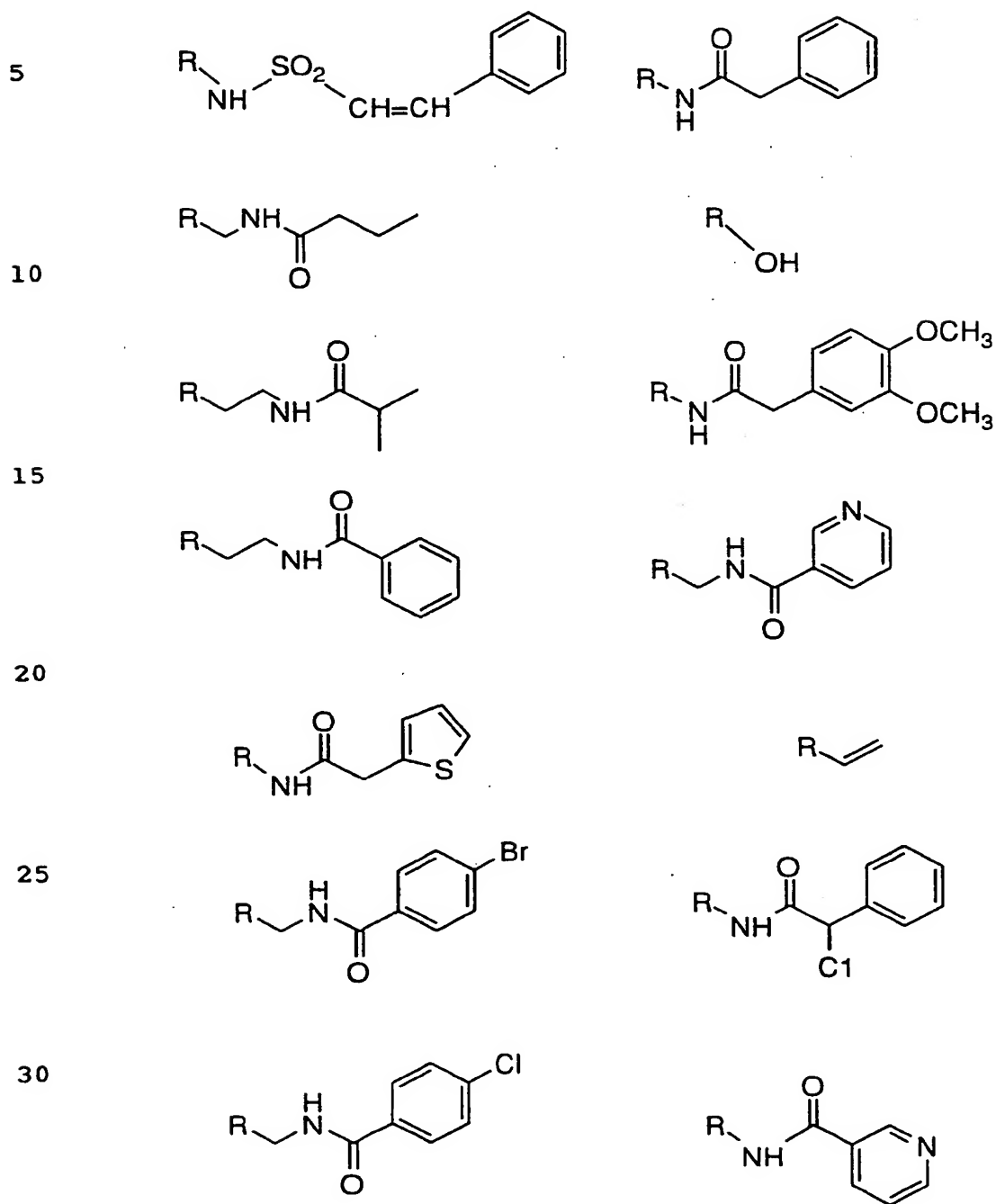


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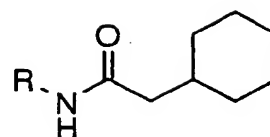
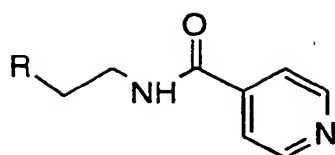
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TABLE 1 (CONT'D)

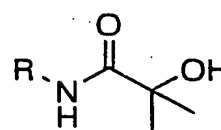
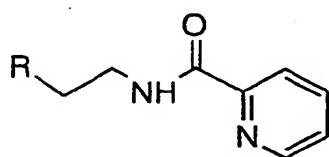
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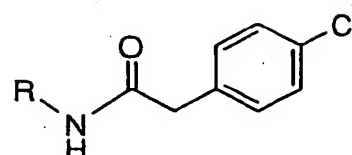
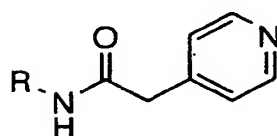
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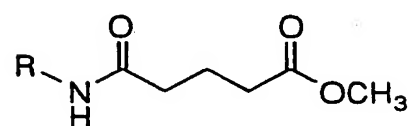
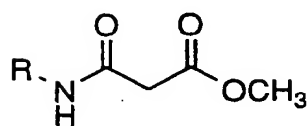
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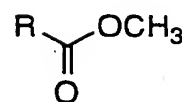
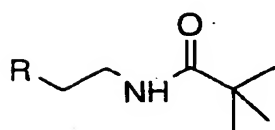
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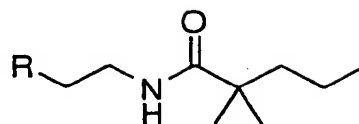


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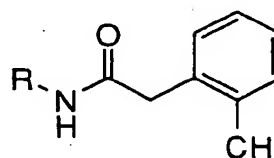
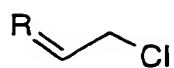
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TABLE 2 CONT'D

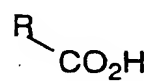
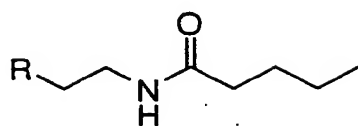
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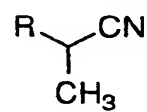
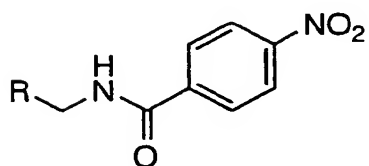
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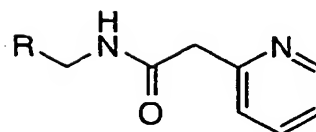
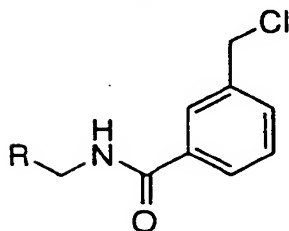
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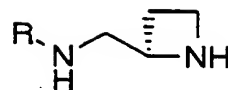
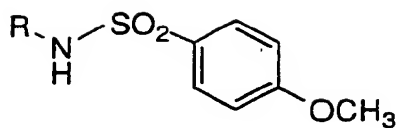


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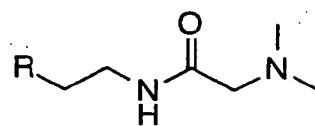
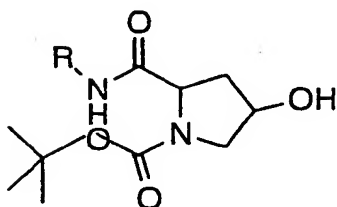
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TABLE 3

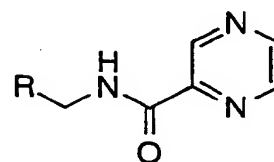
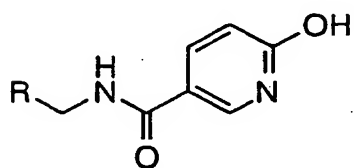
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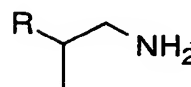
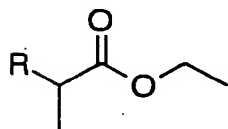
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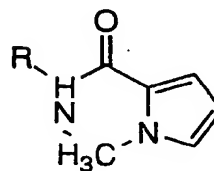
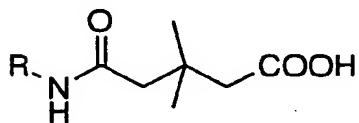
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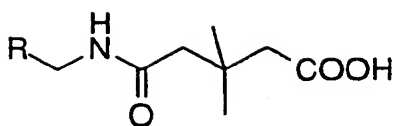
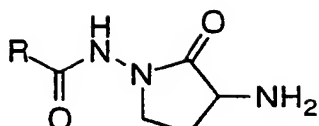
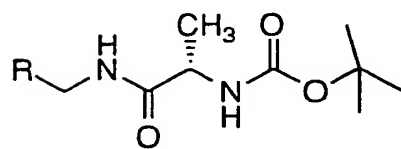
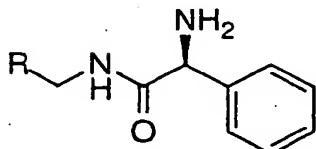
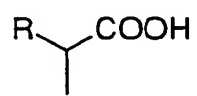
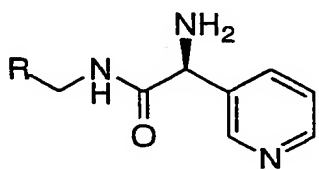
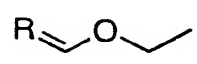
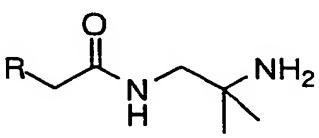
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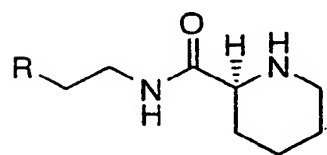
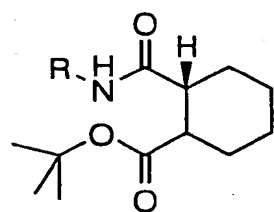
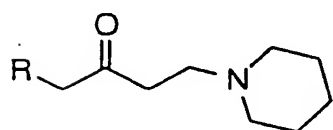
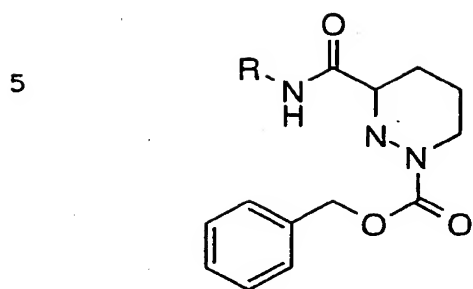
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TABLE 3 CONT'D

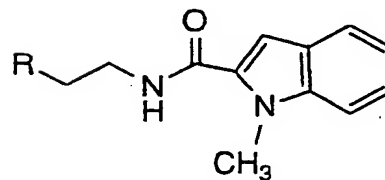
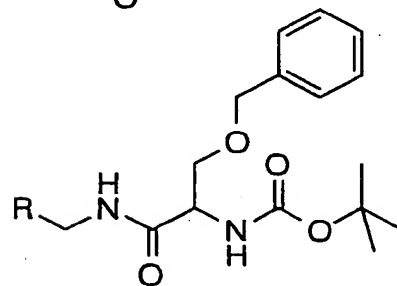
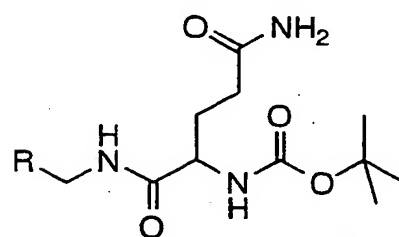
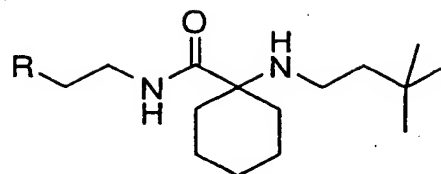
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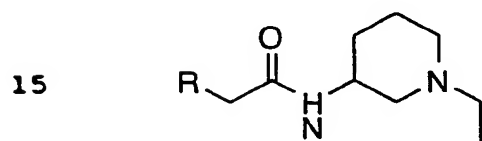
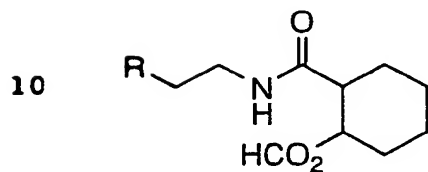
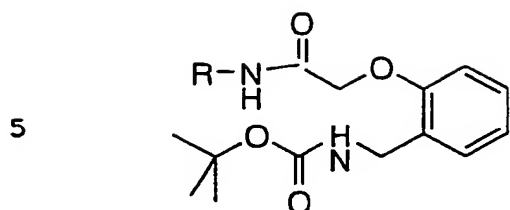
TABLE 4

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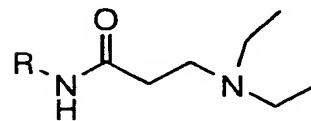
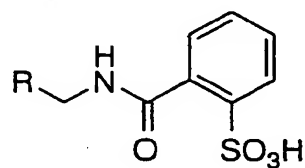
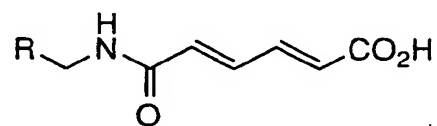
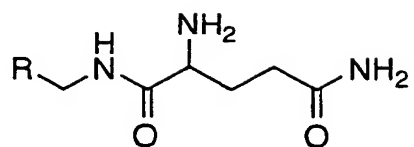
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TABLE 4 CONT'D

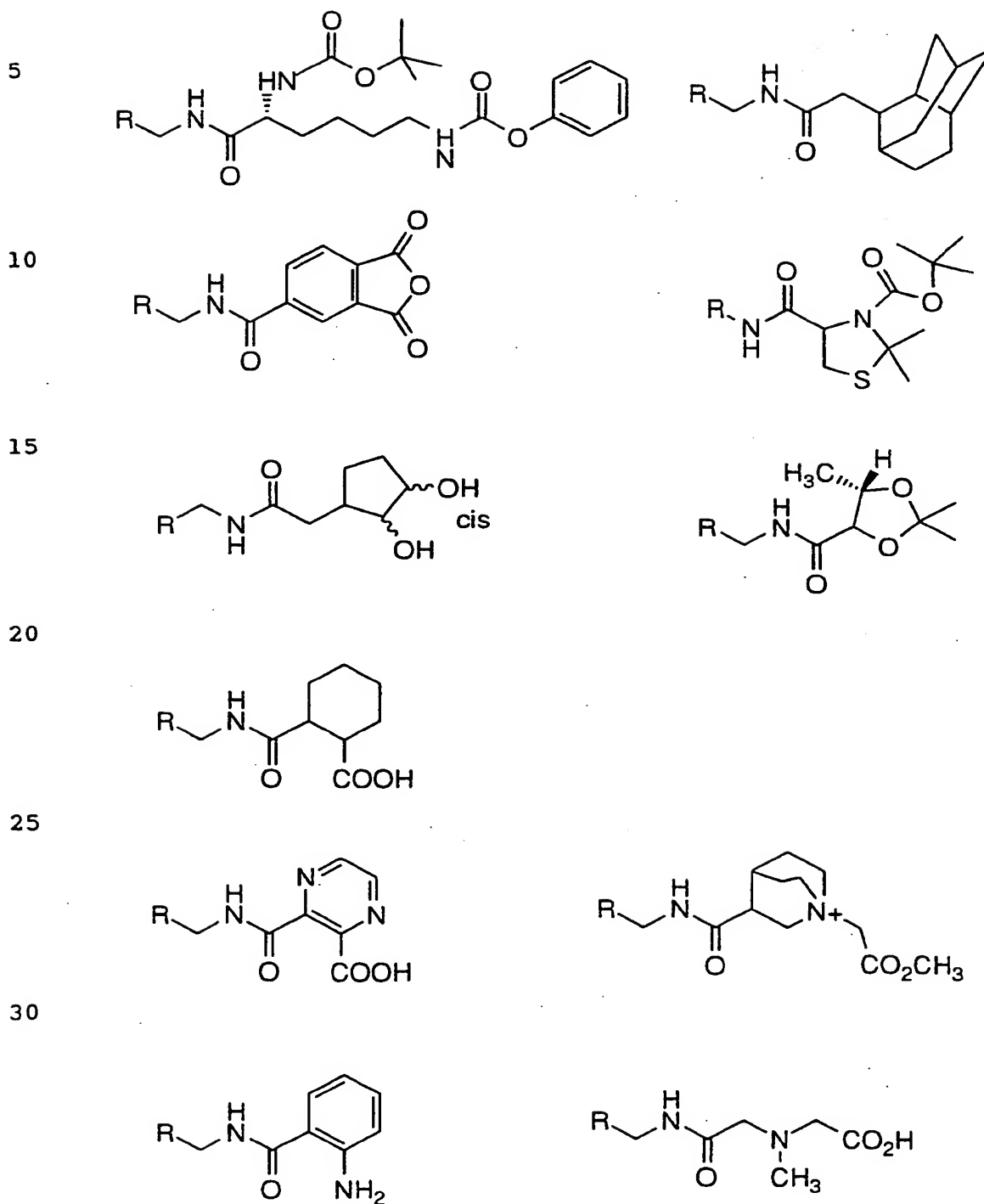
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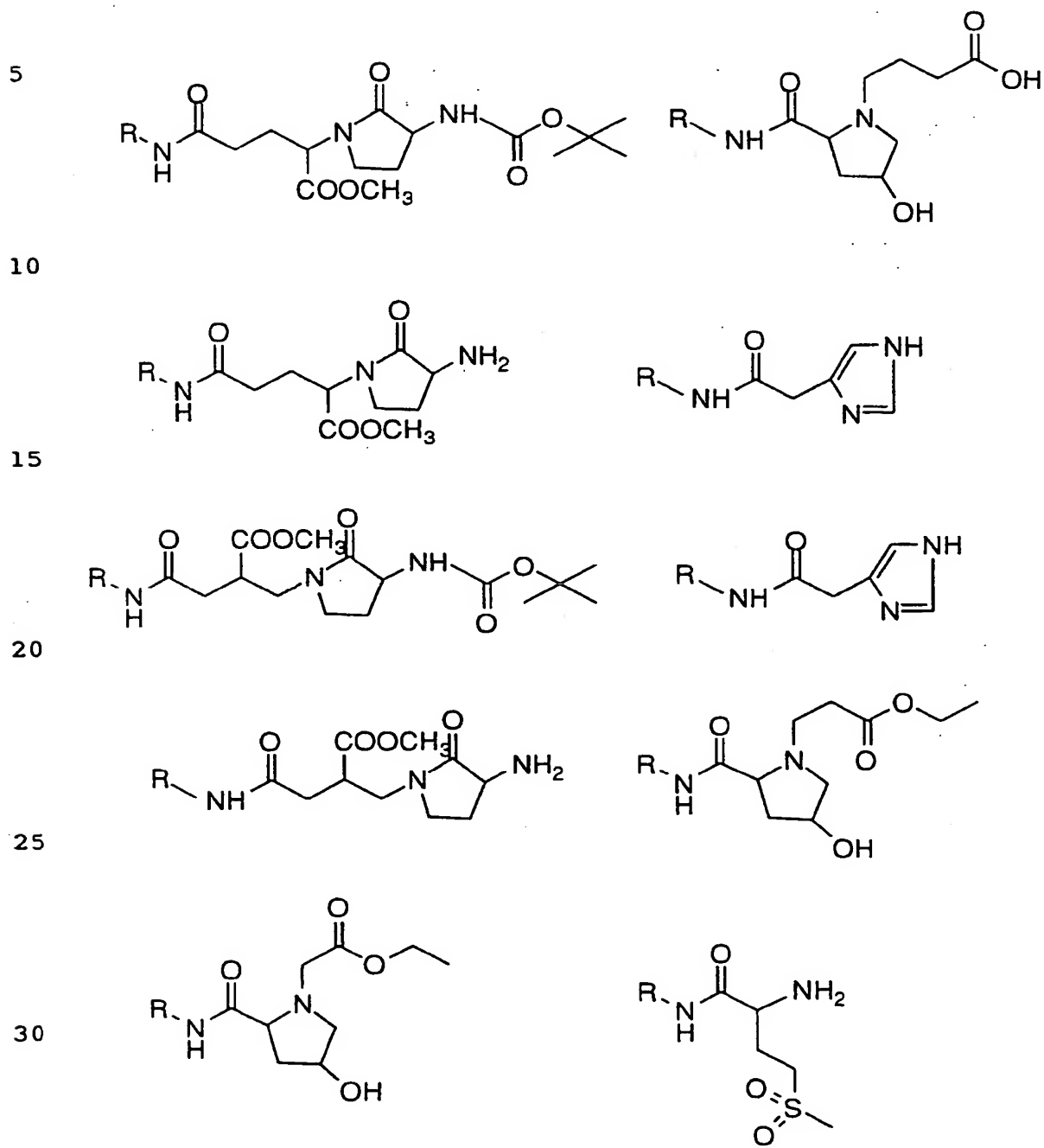
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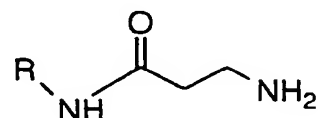
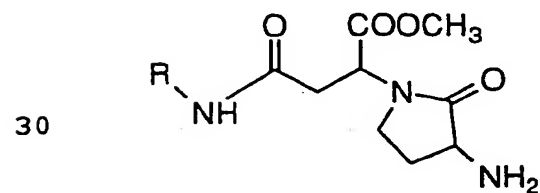
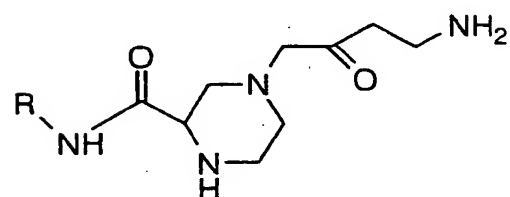
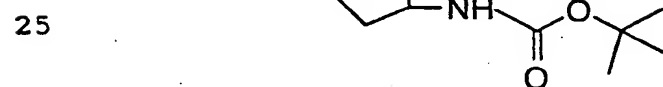
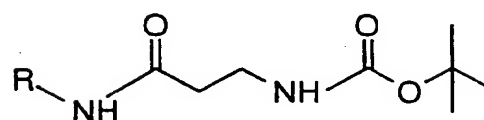
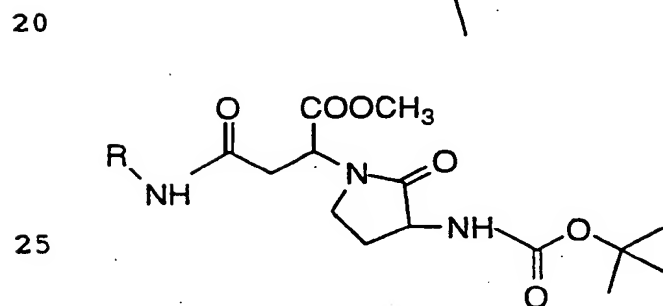
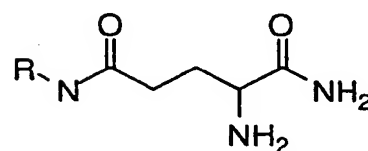
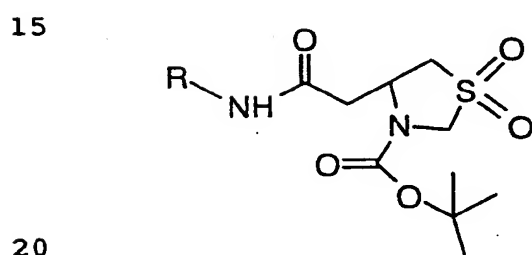
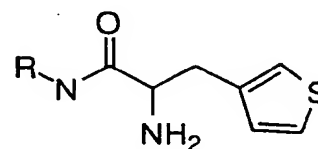
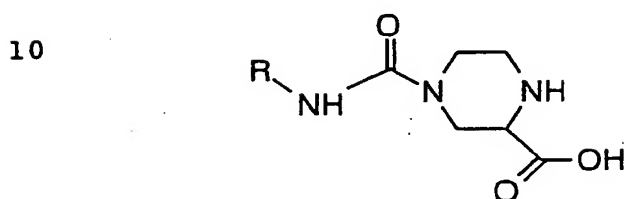
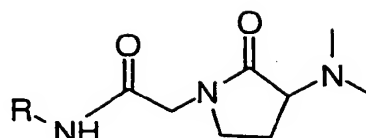
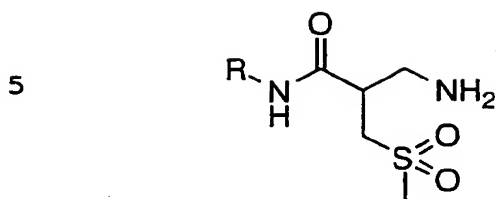
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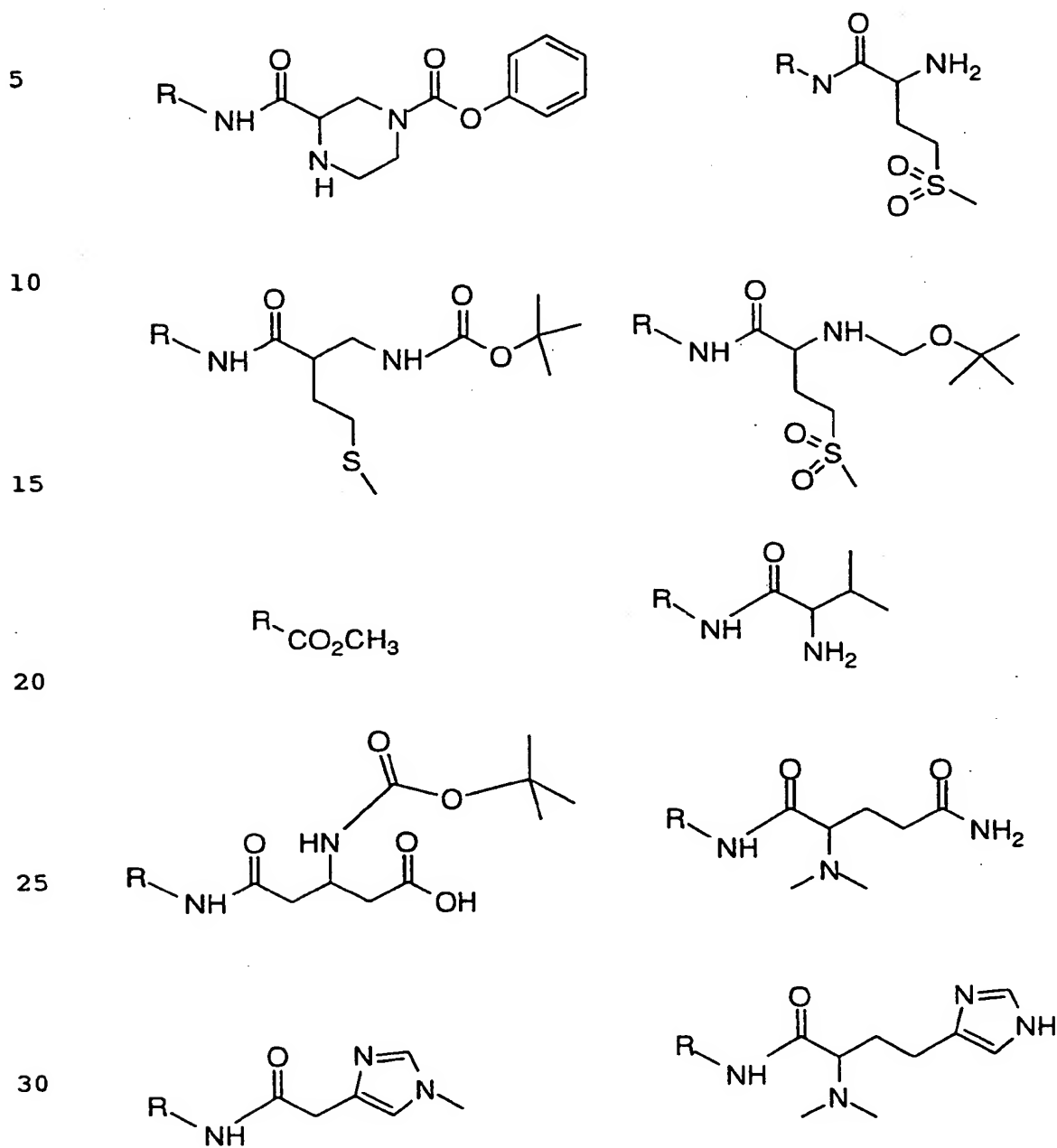
- 168 -

TABLE 6

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TABLE 7

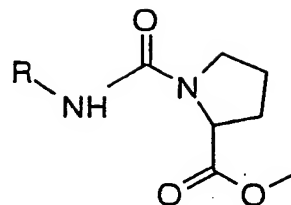
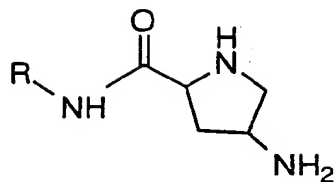
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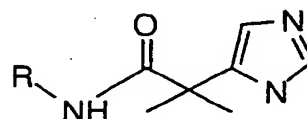
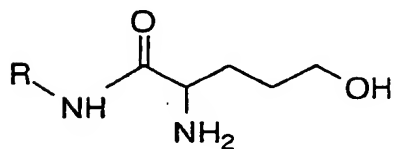
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TABLE 9

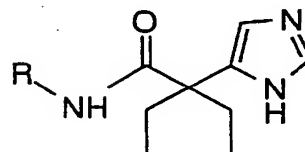
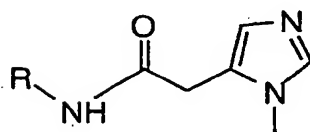
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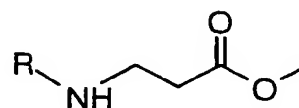
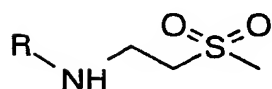
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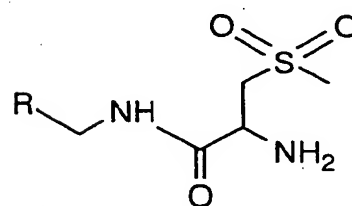
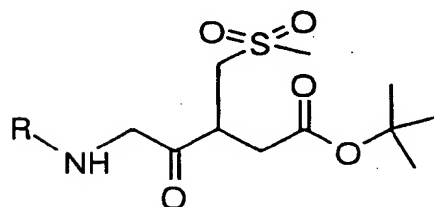
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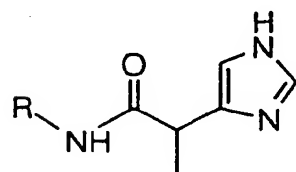
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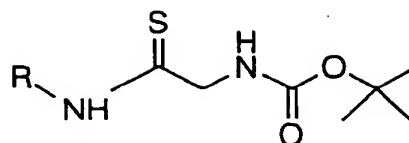
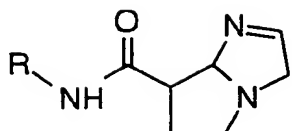
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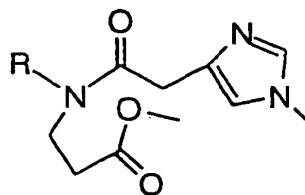
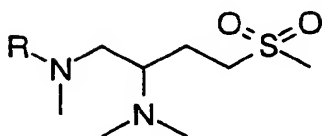
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TABLE 10

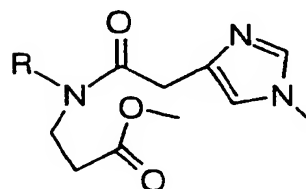
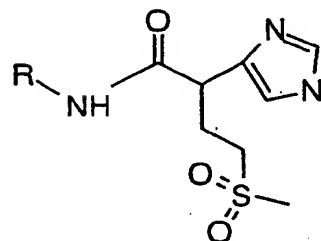
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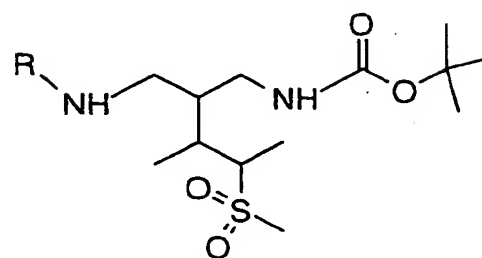
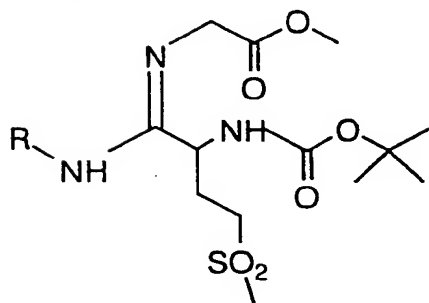
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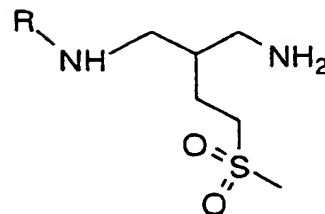
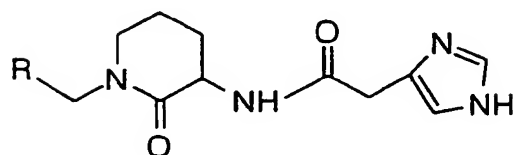
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EXAMPLE 74
RADIOLIGAND BINDING ASSAYS

5 The high affinity binding of [^3H]oxytocin (OT) to uterine tissue and [^3H]arginine vasopressin (AVP) to liver (AVP- $\text{V}_{1\text{a}}$ site) and kidney (AVP- V_2 site) tissue was determined using crude membrane preparations as described previously [Pettibone, D.J., et al., *J. Pharmacol. and Exper. Ther.*, 256(1): 304-308 (1991)]. Uterine tissue was taken from nonpregnant adult Sprague-Dawley rats (Taconic Farms, Germantown, NY) pretreated (18-24 h) with diethylstilbestrol propionate (DES; 300 $\mu\text{g}/\text{kg}$, i.p.). Uterine tissue (full thickness) was also taken with informed consent from nonlabor pregnant women undergoing cesarean section at 38 to 39 weeks gestation (Oregon Health Sciences Center, Portland, OR). Liver and kidney medulla samples were taken from male rats and from human surgical and early postmortem donors (National Disease Research Interchange, Philadelphia PA; Analytical Biological Services, Wilmington, DE).

10 Competition studies were conducted at equilibrium using 1 nM [^3H]OT or 0.5 nM [^3H]AVP in the following buffer: 50 mM Tris, 5 mM MgCl_2 , 0.1% bovine serum albumin. Nonspecific binding was determined using 1 μM unlabeled OT or AVP in their respective assays. The binding reactions were initiated by the addition of tissue preparation and terminated by filtration using a Skatron cell harvester (model 7019, Skatron, Inc., Sterling, VA). K_i values were calculated for each compound using three to six separate IC_{50} determinations ($K_i = \text{IC}_{50}/[1 - c/K_d]$); [Cheng, Y-C; Prusoff, W.H.; *Biochem Pharmacol* 22:3099 (1973)] with mean K_d values obtained from replicate ($n = 3$) equilibrium saturation binding assays (10 point, 100 fold concentration range): [^3H]OT rat uterus, 0.69 nM; human myometrium, 1.1 nM; [^3H]AVP: rat liver, 0.21 nM; rat kidney, 0.27 nM; human liver, 0.27 nM; human kidney, 1.4 nM. Computer analysis of the saturation assays by EBDA/LIGAND [McPherson, G.A.; *Kinetic, Ebda, Ligand, Lowry: A Collection of Radioligand Binding Analysis Programs*, Elsevier Science Publishers, Amsterdam (1985)] indicated that both radioligands apparently bound to single sites in all tissues examined. The final

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protein concentration for the various tissues in each assay ranged from 150 to 300 µg/ml [Lowry, P.H.; Rosebrough, N.J.; Farr, A.L.; Randall, R.J.; *J. Biol. Chem.*, 193:265-275 (1951)].

IC₅₀ values were determined for the [³H]OT and [³H]AVP binding assays by linear regression of the relation log concentration of compound vs. percent inhibition of specific binding. Data is either reported as a given percentage of inhibition at a specified concentration, or if an IC₅₀ was calculated, as a nanomolar concentration. Representative IC₅₀ values of the compounds of the instant invention for rat [³H]OT are given below.

	<u>Example</u>	<u>Result For [³H]OT</u>
15	1	70% inhib. at 1000nM
	2	1100nM
	3	50% inhib. at 1000nM
	4	620nM
	5	190nM
20	6	60% inhib. at 1000nM
	7	54% inhib. at 1000nM
	8	140nM
	9	68% inhib. at 1000nM
	10	140nM
25	11	69% inhib. at 1000nM
	12	37% inhib. at 100nM
	13	180nM
	14	76% inhib. at 1000nM
	15	160nM
30	16	61nM
	17	45nM
	18	52% inhib. at 100nM
	19	150nM
	20	50% inhib. at 100nM
	21	61nM

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	<u>Example</u>	<u>Result For [³H]OT</u>
5	22	58.8nM
	25	26% inhib. at 10000nM
	26	34% inhib. at 1000nM
	27	47nM
	28	82nM
10	29	31nM
	30	45nM
	32	36% inhib. at 10000nM
	33	30% inhib. at 1000nM
	34	48% inhib. at 1000nM
15	35	43% inhib. at 1000nM
	36	67nM
	38	33% inhib. at 1000nM
	39	8500nM
	40	71% inhib. at 10000nM
20	41	120nM
	42	96.5nM
	43	4300nM
	44	39% inhib. at 100nM
	45	25% inhib. at 100nM
25	46	36% inhib. at 100nM
	47	4600nM
	48	90nM
	49	54nM
	50	71% inhib. at 1000nM
30	51	84% inhib. at 1000nM
	52	290nM
	67	7.6 nM
	73	45 nM

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Binding (K_i) of compounds to Human OT, Human AVP-V_{1a} and Human AVP-V₂:

	<u>Example</u>	<u>OT</u>	<u>AVP-V_{1a}</u>	<u>AVP-V₂</u>
5	67	3.7 nM	1.4 nM	1600 nM
	73	3.8 nM	2.7 nM	--

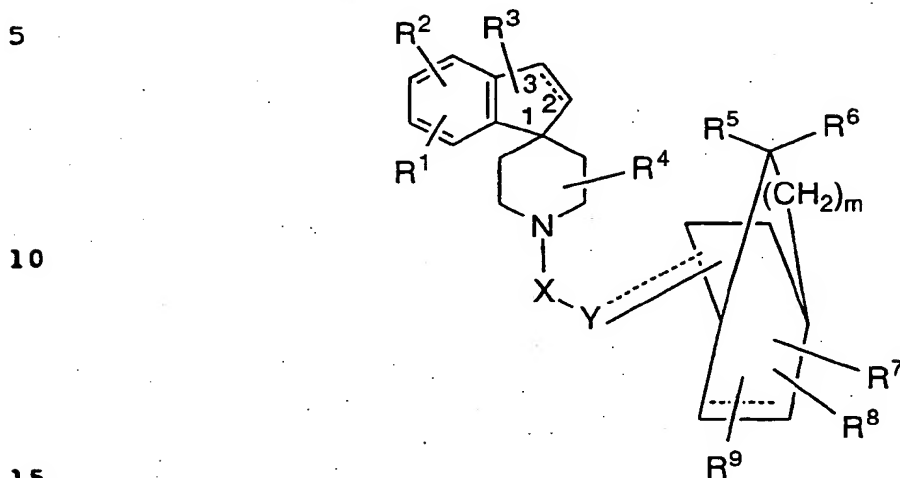
While the invention has been described and illustrated with reference to certain preferred embodiments thereof, those skilled in the art will appreciate that various changes, modifications and substitutions can be made therein without departing from the spirit and scope of the invention. For example, effective dosages other than the preferred dosages as set forth hereinabove may be applicable as a consequence of variations in the responsiveness of the mammal being treated for prevention of preterm labor, or for other indications for the compounds of the invention indicated above. Likewise, the specific pharmacological responses observed may vary according to and depending upon the particular active compound selected or whether there are present pharmaceutical carriers, as well as the type of formulation and mode of administration employed, and such expected variations or differences in the results are contemplated in accordance with the objects and practices of the present invention. It is intended, therefore, that the invention be limited only by the scope of the claims which follow and that such claims be interpreted as broadly as is reasonable.

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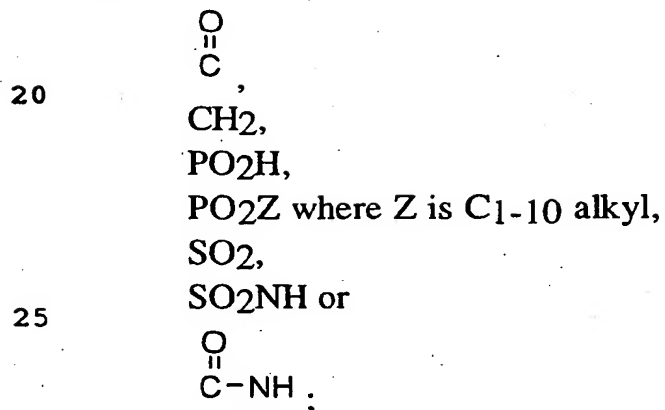
IN THE CLAIMS:

1. A compound of the formula

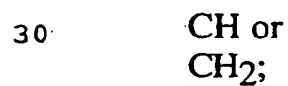


wherein

X is



Y is absent or is



m is an integer of from zero to one;

n is an integer of from zero to five;

p is an integer of from zero to five;

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q is an integer of from zero to five;

R¹ and R² are each independently

5 hydrogen,
 halogen,
 hydroxy,
 C₁-10 alkyl,
 C₁-10 alkoxy or
10 trifluoromethyl;

R³ is

 hydrogen,
 halogen,
 hydroxy or
15 oxo with the proviso that when R³ is oxo then the 2,3 bond
 is saturated;

R⁴ is

20 hydrogen,
 phenyl, or
 C₁-10 alkyl,

R⁵ and R⁶ are independently

25 hydrogen,
 C₁-10 alkyl or
 C₁-10 hydroxyalkyl; or

R⁵ and R⁶ together are

30 oxo or
 unsubstituted or substituted C₃-6 cycloalkyl, where said
 substituents are
 hydroxy,
 C₁-10 alkyl,
 C₁-10 hydroxyalkyl,

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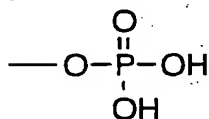
C1-10 alkoxy or
C1-3 alkoxyalkoxyalkoxyalkyl;

5 R⁷ and R⁸ are independently
hydrogen or
hydroxyl; or

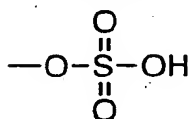
10 R⁷ and R⁸ are, together with the carbons to which they are attached,
joined to form a 5-membered heterocyclic ring containing 2 hetero
atoms where said hetero atoms are N and O;

R⁹ is

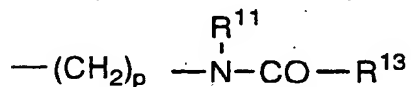
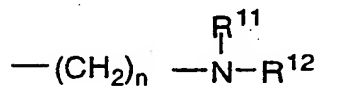
15 C7-10 alkoxy,
C1-10 alkoxycarbonyl,
C1-10 alkoxycarbonylalkylaminocarbonyl,
cyano,



20 C1-10 alkyl substituted phosphonate,



25 C1-10 alkyl substituted sulfonate,



30 $\text{---(CH}_2\text{)}_q\text{---CO---NH---R}^{14}$, or

unsubstituted or substituted C1-10 alkyl where said
substituent is

R¹⁰;

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R¹⁰ is

hydroxyl,
carboxyl,
C1-10 alkoxy,
5 C1-10 alkoxycarbonyl,
R¹⁵ or
cyano;

R¹¹ is

10 hydrogen,
C1-10 alkyl,
C1-10 carboxyalkyl or
C1-10 alkoxycarbonylalkyl;

R¹² is

15 hydrogen,
C1-10 alkylsulfonyl,
C1-10 alkarylsulfonyl,
C1-10 aralkylsulfonyl,
20 C1-10 alkoxyarylsulfonyl,
aminosulfonyl,
C1-10 alkylaminosulfonyl,
C1-10 dialkylaminosulfonyl,
unsubstituted or substituted C4-15 cycloalkylalkyl, bicycloalkyl or
25 tricycloalkyl where said substituent is
oxo or
sulfonyl substituted by unsubstituted or substituted C7-15
cycloalkyl, bicycloalkyl or tricycloalkyl where said
substituents are
30 oxo,
oxime or
hydroxy;

R¹³ is

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amino,
C₁₋₁₀ alkylamino,
C₁₋₁₀ alkyl which is unsubstituted or mono- or di-substituted by
R¹⁶,
5 C₂₋₁₀ alkenyl which is unsubstituted or substituted by R¹⁶,
phenyl substituted by R¹⁷,
unsubstituted or substituted C₃₋₈ cycloalkyl where said
substituents are
C₁₋₁₀ alkyl or
10 carboxy,
N disubstituted by C₁₋₁₀ alkyl,
unsubstituted or substituted C₇₋₁₅ bicycloalkyl or tricycloalkyl
where said substituent is
carboxy,
15 C₁₋₁₀ alkoxy or
R¹⁸;

R¹⁴ is
C₁₋₁₀ alkyl,
20 C₁₋₁₀ aminoalkyl,
C₁₋₁₀ alkoxycarbonylalkyl, or
C₁₋₁₀ carboxyalkyl,

R¹⁵ is
25 unsubstituted or substituted 5 membered heterocyclic rings
containing 1 hetero atom where said hetero atom is N and said
substituents are
oxo,
amino,
30 C₁₋₁₀ alkylamino,
C₁₋₁₀ carboxyalkylcarbonylamino,
C₁₋₁₀ dicarboxyalkylamino or
C₁₋₁₀ alkyloxycarbonylalkylamino;

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R¹⁶ is

unsubstituted or substituted C₄₋₈ cycloalkyl where said
substituents are

- 5 hydroxy or
 carboxy,
 C₁₀₋₁₅ bi- or tricycloalkyl,
 halogen,
 hydroxy,
 carboxy,
10 oxo,
 oxime,
 C₁₋₁₀ alkylthio,
 C₁₋₁₀ alkylsulfinyl,
 C₁₋₁₀ alkylsulfonyl,
15 C₁₋₁₀ alkoxy carbonyl,
 R²⁰,
 R²¹,
 amino,
 aminocarbonyl,
20 C₁₋₁₀ dialkylaminocarbonyl,
 C₁₋₁₀ alkylamino,
 C₁₋₁₀ dialkylamino,
 C₁₋₁₀ alkylcarbamate,
 C₁₋₁₀ alkylcarbonate,
25 C₁₋₁₀ alkylureide,
 C₁₋₁₀ aralkylcarbamate,
 unsubstituted or substituted aryloxy where said substituents
 are
- 30 amino,
 C₁₋₁₀ alkyl or
 C₁₋₁₀ aminoalkyl,
 C₁₋₁₀ aralkoxy,
 unsubstituted or substituted C₁₋₁₀ alkaryloxy where said
 substituent is

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5 C₁-10 alkylcarbamate,
N disubstituted by C₁-10 alkyl and C₁-10 carboxyalkyl or
N tri-substituted by two C₁-10 alkyls and by C₁-10
alkoxycarbonylalkyl with the proviso that a trifluoroacetic
acid counterion be present;

10 R¹⁷ is
amino,
halogen,
C₁-10 alkyl,
C₁-10 alkoxy,
nitro,
phenylcarbonyl or
15 unsubstituted or substituted 5 membered heterocyclic rings
containing 1 hetero atom where said hetero atom is O and
wherein said substituent is
oxo;

20 R¹⁸ is unsubstituted or substituted heterocyclic rings selected from
azetidinyI,
pyrrolidinyl,
pyrrolyl,
piperidinyl,
25 piperizinyl,
pyridinyl,
pyrimidinyl,
tetrahydrofuranyl,
furanyl,
dioxolanyl,
30 thienyl,
1, 3-thiazolidinyl or
tetrahydrooxazolyl; where said substituents are one or more of
oxo,
hydroxy,

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5 carboxy,
amino,
C1-10 carboxyalkyl,
C1-10 alkyl,
C1-10 alkoxy,
C1-10 aralkoxy,
C1-10 alkaryloxy,
C1-10 alkoxy carbonyl,
C1-10 alkoxy carbonylamino,
10 C1-10 alkoxy carbonylalkyl,
C1-10 aralkoxy carbonyl or
substituted or unsubstituted phenyl where said substituents
are

15 C1-5 alkyl,
carboxy or
halogen;

R²⁰ is unsubstituted or substituted heterocyclic rings selected from
20 azetidinyI,
pyrrolidinyl,
pyrrolyl,
tetrahydroimidazolyl,
imidazolyl,
25 tetrazolyl,
piperidinyl,
pyridinyl,
hexahydroazepinyl,
thienyl,
1, 3-thiazolidinyl or
30 tetrahydrothiazinyl; where said substituents are one or
more of

C1-10 alkyl,
C1-10 aralkyl,
C1-10 aralkoxy,

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C1-10 alkaryl,
 amino,
 C1-10 alkylamino,
 C1-10 dialkylamino,
 5 oxo,
 oxime,
 fused phenyl,
 C1-10 alkoxy carbonyl,
 10 C1-10 alkyl carbonate,
 C1-10 alkylureide,
 C1-10 alkyl carbamate, or
 unsubstituted or substituted 5-membered heterocyclic
 rings having 1 hetero atom where said hetero atom is
 15 N and said substituent is one or more of
 oxo or
 fused phenyl;

R21 is
 20 unsubstituted or substituted phenyl where said substituents are
 halogen,
 C1-10 alkyl,
 C1-10 carboxyalkyl,
 C1-10 alkoxy,
 25 5- or 6-membered heterocyclic rings having 1 or 2 hetero
 atoms where said hetero atoms are N or S,
 hydroxy,
 carboxy or
 30
$$\begin{array}{c} \text{O} \\ \parallel \\ \text{—O—S—OH} \\ \parallel \\ \text{O} \end{array}$$

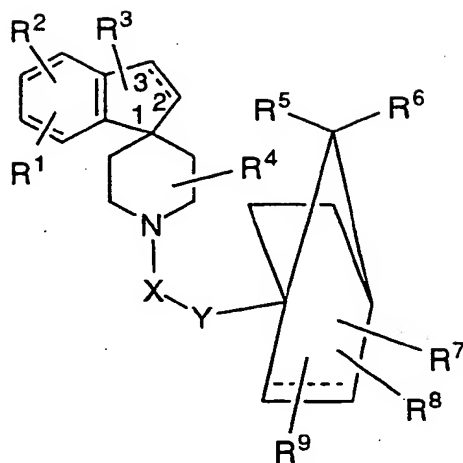
and the pharmaceutically acceptable salts thereof.

2. The compound as claimed in Claim 1, of the formula

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5

10



wherein

X is

15

CH₂,PO₂H,PO₂Z where Z is C₁-10 alkyl, orSO₂;

20

R¹ and R² are each independently

hydrogen,

halogen or

C₁-10 alkyl;

25

R⁴ is

hydrogen or

phenyl;

30

R⁵ and R⁶ are independently

hydrogen or

C₁-10 alkyl; orR⁵ and R⁶ together are

oxo or

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unsubstituted or substituted C3-6 cycloalkyl, where said substituents are

hydroxy,
C1-10 hydroxyalkyl or
C1-3 alkoxyalkoxyalkoxyalkyl;

R⁹ is

C7-10 alkoxy,
C1-10 alkoxycarbonyl,
C1-10 alkoxycarbonylalkylaminocarbonyl,

C1-10 alkyl substituted $\begin{array}{c} \text{O} \\ \parallel \\ -\text{O}-\text{P}-\text{OH} \\ | \\ \text{OH} \end{array}$,

$\begin{array}{c} \text{O} \\ \parallel \\ -\text{O}-\text{S}-\text{OH} \\ \parallel \\ \text{O} \end{array}$,

phosphonate,
C1-10 alkyl substituted sulfonate,

$\begin{array}{c} \text{R}^{11} \\ | \\ -(\text{CH}_2)_n - \text{N} - \text{R}^{12} \end{array}$,

$\begin{array}{c} \text{R}^{11} \\ | \\ -(\text{CH}_2)_p - \text{N} - \text{CO} - \text{R}^{13} \end{array}$,

unsubstituted or substituted C1-10 alkyl where said substituent is R¹⁰;

R¹² is

hydrogen,
C1-10 alkylsulfonyl,
C1-10 alkarylsulfonyl,

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C1-10 alkoxyarylsulfonyl,
aminosulfonyl,
C1-10 dialkylaminosulfonyl,
unsubstituted or substituted C3-15 cycloalkylalkyl where said
5 substituent is

oxo or
sulfonyl substituted by unsubstituted or substituted C3-15
cycloalkyl where said substituent is
10 oxo;

R¹⁴ is

C1-10 alkyl,
C1-10 aminoalkyl or
15 C1-10 alkoxycarbonylalkyl;

R¹⁶ is

unsubstituted or substituted C5-6 cycloalkyl where said substituent
is

20 hydroxy,
C10-15 tricycloalkyl,
halogen,
hydroxy,
carboxy,

25 oxo,
C1-10 alkylthio,
C1-10 alkylsulfonyl,
C1-10 alkoxycarbonyl,
R²⁰,
R²¹,

30 amino,
C1-10 alkylamino,
C1-10 dialkylamino,
C1-10 alkylcarbamate,
C1-10 aralkylcarbamate,

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unsubstituted or substituted aryloxy where said substituents are

amino,

C₁-10 alkyl or

C₁-10 aminoalkyl,

C₁-10 aralkoxy,

unsubstituted or substituted C₁-10 alkaryloxy where said substituent is

C₁-10 alkyl carbamate,

N disubstituted by C₁-10 alkyl and C₁-10 carboxyalkyl; or

N tri-substituted by two C₁-10 alkyls and by C₁-10

alkoxycarbonylalkyl with the proviso that a counterion be

present from the group consisting of C₁-5 halogenated

carboxylic acids;

R¹⁸ is unsubstituted or substituted heterocyclic rings selected from

azetidiny,

pyrrolidiny,

pyrroly,

piperidiny,

piperiziny,

pyridiny,

pyrimidiny,

tetrahydrofurany,

furany,

dioxolany,

thieny,

1, 3-thiazolidiny or

tetrahydrooxazolyl, where said substituents are one or more of

oxo,

hydroxy,

carboxy,

C₁-10 carboxyalkyl,

C₁-10 alkyl,

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5 C1-10 alkoxy,
C1-10 aralkoxy,
C1-10 alkoxycarbonyl,
C1-10 alkoxycarbonylalkyl or
C1-10 aralkoxycarbonyl;

10 R²⁰ is unsubstituted or substituted heterocyclic rings selected from
hexahydroazepinyl,
pyrrolidinyl,
pyrrolyl,
tetrahydroimidazolyl,
imidazolyl,
15 tetrazolyl,
piperidinyl,
pyridinyl,
azetidiny,
thienyl,
1, 3-thiazolidinyl or
20 tetrahydrothiazinyl; where said substituents are one or more of
C1-10 alkyl,
C1-10 aralkyl,
C1-10 aralkoxy,
amino,
25 oxo,
fused phenyl,
C1-10 alkoxycarbonyl,
C1-10 alkylcarbamate, or
unsubstituted or substituted 5-membered heterocyclic rings
30 having 1 hetero atom where said hetero atom is N and said
substituent is
oxo or
fused phenyl;

R²¹ is

- 191 -

unsubstituted or substituted phenyl where said substituents are

C1-10 alkyl,

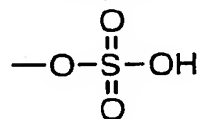
C1-10 carboxyalkyl,

C1-10 alkoxy,

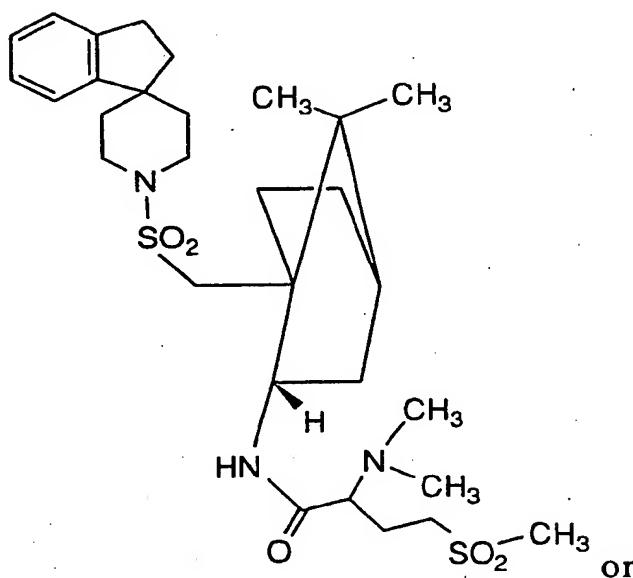
5- or 6-membered heterocyclic rings having 1 or 2 hetero atoms where said hetero atoms are N or S,

hydroxy,

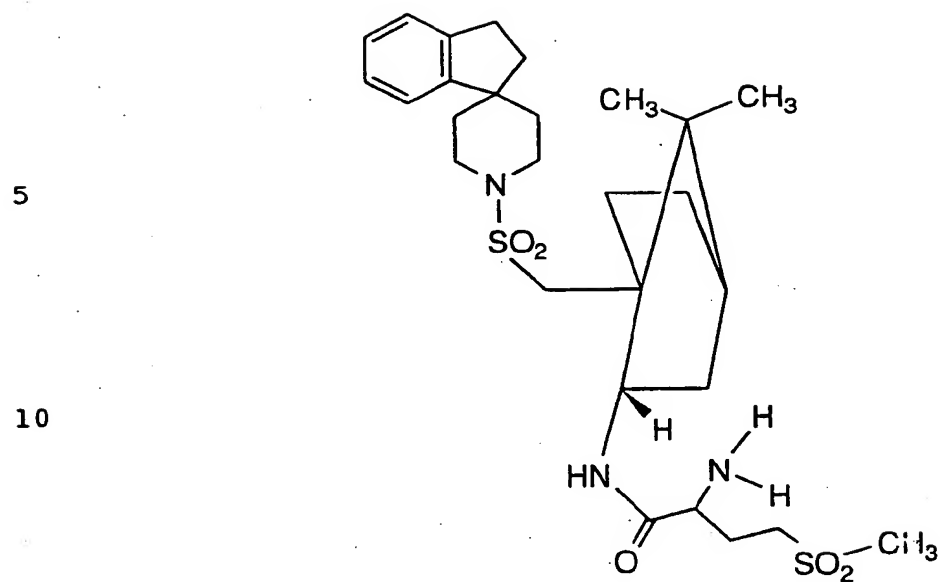
carboxy or



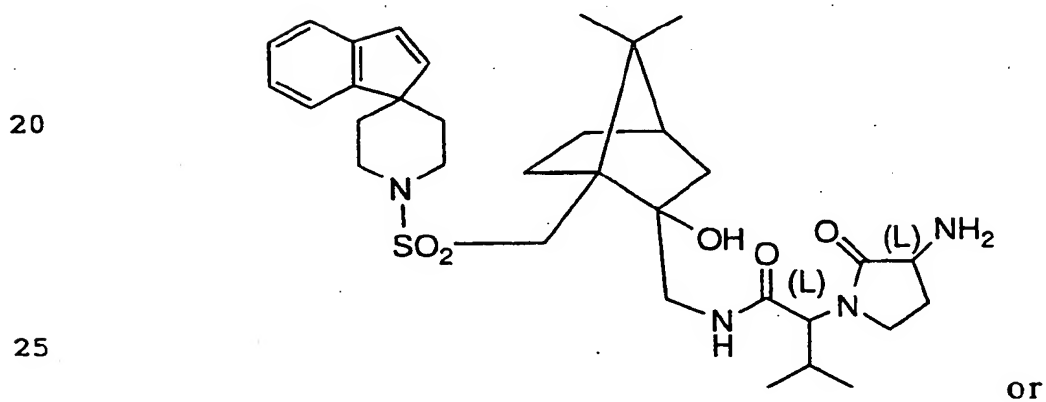
3. The compound of Claim 2, selected from



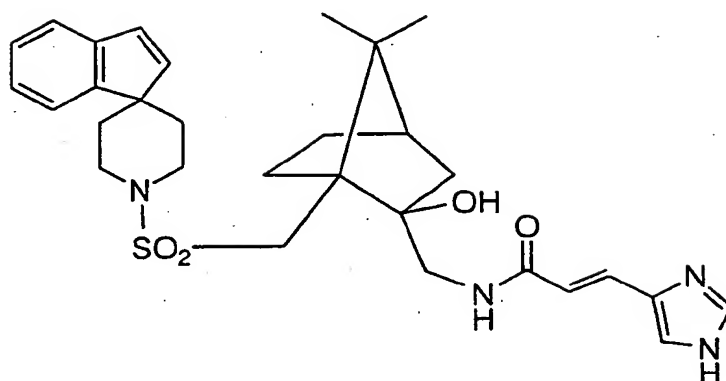
- 192 -



4. The compound of Claim 2, selected from



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5

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5. A pharmaceutical composition, comprising a compound as claimed in Claim 1 in a pharmacologically effective amount for antagonizing the binding of oxytocin to its receptor site, and a pharmaceutically acceptable carrier.

6. A method of preventing preterm labor in a mammal in need thereof, comprising the step of administering to said mammal a pharmacologically effective amount of a compound as claimed in Claim 1.

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7. A method of treating dysmenorrhea in a mammal in need thereof, comprising the step of administering to said mammal a pharmacologically effective amount of a compound as claimed in Claim 1.

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8. A method of stopping labor preparatory to cesarean delivery in a mammal in need thereof, comprising the step of administering to said mammal a pharmacologically effective amount of a compound as claimed in Claim 1.

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9. A method of antagonizing the binding of oxytocin to its receptor site in a mammal, comprising the step of administering to said mammal a pharmacologically effective amount of a compound as claimed in Claim 1.

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5 10. A method of antagonizing vasopressin from binding to its receptor site in a mammal, comprising the step of administering to said mammal a pharmacologically effective amount of a compound as claimed in Claim 1.

10 11. A method of inducing vasodilation in a mammal in need thereof, comprising the step of administering to said mammal a pharmacologically effective amount of the compound as claimed in Claim 1.

15 12. A method of treating hypertension in a mammal in need thereof, comprising the step of administering to said mammal a pharmacologically effective amount of the compound as claimed in Claim 1.

20 13. A method of inducing diuresis in a mammal in need thereof, comprising the step of administering to said mammal a pharmacologically effective amount of the compound as claimed in Claim 1.

25 14. A method of inhibiting platelet agglutination in a mammal in need thereof, comprising the step of administering to said mammal a pharmacologically effective amount of the compound as claimed in Claim 1.

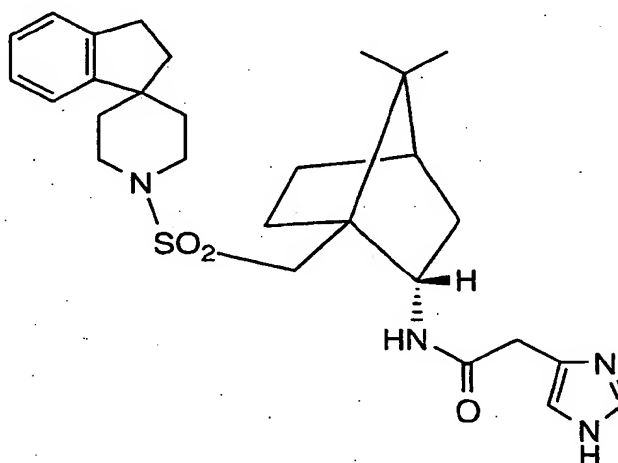
30 15. A pharmaceutical composition comprising a pharmaceutically acceptable carrier and a pharmacologically effective amount of a compound as claimed in Claim 4.

 16. A method of preventing preterm labor in a mammal in need thereof, comprising the step of administering to said mammal a pharmacologically effective amount of a compound as claimed in Claim 4.

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17. A method of treating dysmenorrhea in a mammal in need thereof, comprising the step of administering to said mammal a pharmacologically effective amount of a compound as claimed in Claim 4.

18. A compound of the formula



and the pharmaceutically acceptable salts thereof.

19. A pharmaceutical composition, comprising the compound as claimed in Claim 18 in a pharmacologically effective amount for antagonizing the binding of oxytocin to its receptor site, and a pharmaceutically acceptable carrier.

20. A method of preventing preterm labor in a mammal in need thereof, comprising the step of administering to said mammal a pharmacologically effective amount of a compound as claimed in Claim 18.

21. A method of treating dysmenorrhea in a mammal in need thereof, comprising the step of administering to said mammal a pharmacologically effective amount of a compound as claimed in

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Claim 18.

22. A method of stopping labor preparatory to cesarean
delivery in a mammal in need thereof, comprising the step of
5 administering to said mammal a pharmacologically effective amount of
a compound as claimed in Claim 18.

23. A method of antagonizing the binding of oxytocin to
its receptor site in a mammal, comprising the step of administering to
10 said mammal a pharmacologically effective amount of a compound as
claimed in Claim 18.

24. A method of treating preterm labor in a mammal in
need thereof, comprising administering to said mammal a
15 pharmacologically effective amount of a compound which binds to a
human oxytocin receptor with a binding affinity which is no more than
ten-fold higher or ten-fold lower than the binding affinity with which
the compound binds to a human arginine-vasopressin-V₁ (AVP-V_{1a})
20 receptor.

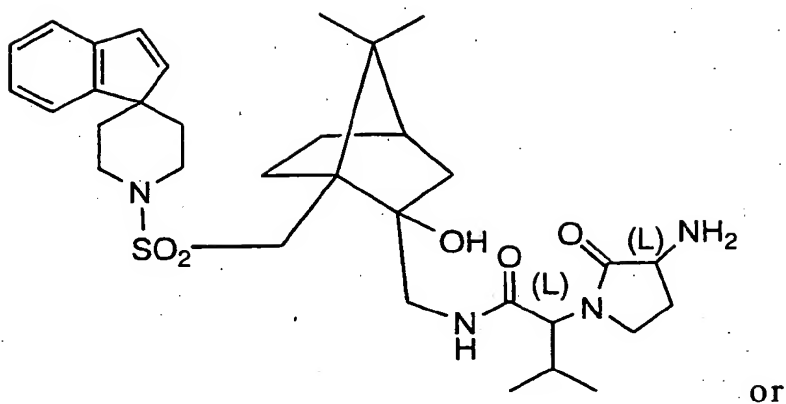
25. The method of Claim 24, wherein the compound
binds to the human oxytocin receptor with a binding affinity which is no
more than five-fold higher or five-fold lower than the binding affinity
25 with which the compound binds to the human AVP-V_{1a} receptor.

26. The method of Claim 25, wherein the compound is
selected from

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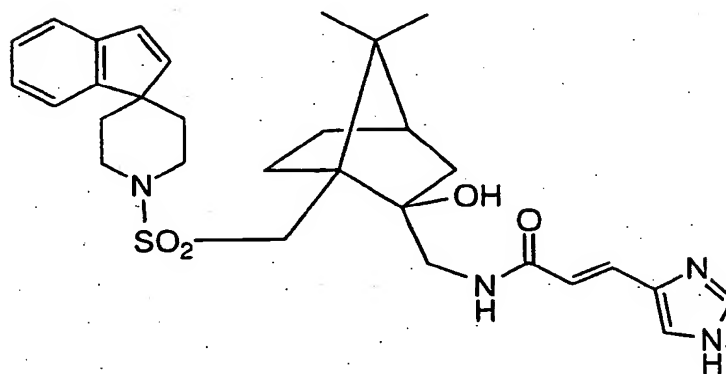
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or

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27. A method of treating dysmenorrhea in a mammal in need thereof, comprising administering to said mammal a pharmacologically effective amount of a compound which binds to a human oxytocin receptor with a binding affinity which is no more than ten-fold higher or ten-fold lower than the binding affinity with which the compound binds to a human arginine-vasopressin-V₁ (AVP-V_{1a}) receptor.

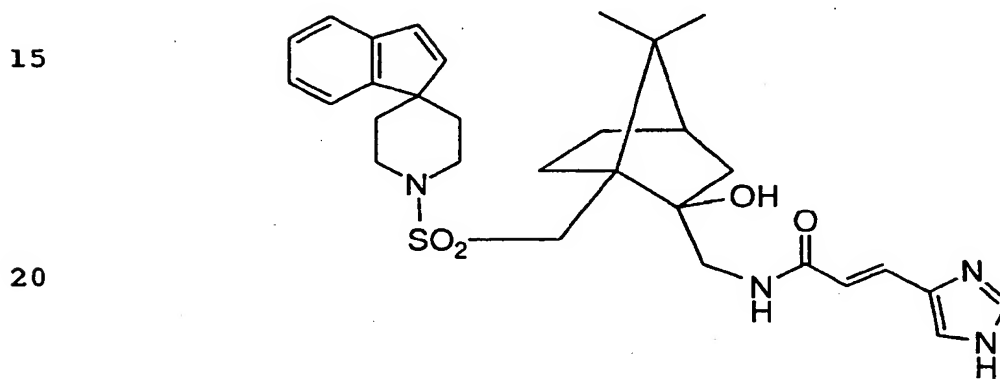
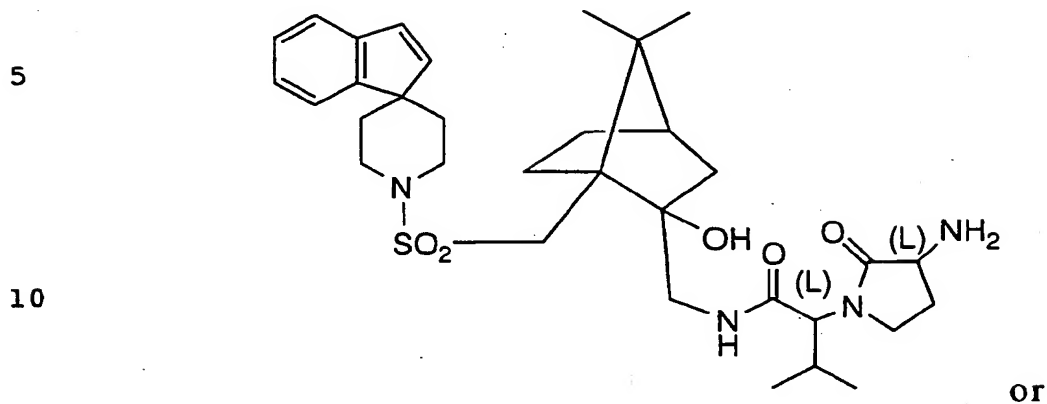
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28. The method of Claim 27, wherein the compound binds to the human oxytocin receptor with a binding affinity which is no more than five-fold higher or five-fold lower than the binding affinity with which the compound binds to the human AVP-V_{1a} receptor.

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29. The method of Claim 28, wherein the compound is selected from



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US94/13483

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : Please See Extra Sheet.

US CL : 546/17; 514/278

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 546/17; 514/278

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CAS ONLINE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X -- Y -- A	US, A, 5,204,349 (Bock et al.) 20 APRIL 1993, see formula I.	1, 2, 5-12, 15-17 ----- 3-4, 18-23, 26, 29 ----- 13, 14



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:	* T	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
* A		document defining the general state of the art which is not considered to be of particular relevance
* E	* X	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
* L	* Y	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
* O		document referring to an oral disclosure, use, exhibition or other means
* P	* A	document member of the same patent family
		document published prior to the international filing date but later than the priority date claimed

Date of the actual completion of the international search

14 FEBRUARY 1995

Date of mailing of the international search report

13 MAR 1995

Name and mailing address of the ISA/US
Commissioner of Patents and Trademarks
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Authorized officer

MARK L. BERCH *aco*

Telephone No. (703) 308-1235

Form PCT/ISA/210 (second sheet)(July 1992)*

INTERNATIONAL SEARCH REPORT

Int. national application No.

PCT/US94/13483

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X -- Y -- A	US, A, 5,091,387 (Evans et al.) 25 February 1992, see Examples 9-11, 13-15, 18-21, 26.	1, 2, 5-12, 15-17 ----- 4, 18-23, 26, 29 ----- 3, 13, 14
X	EP, A, 0,486,280 (Freidinger et al.) 20 MAY 1992, see entire document.	1-23, 26, 29
X -- Y -- A	EP, A, 0,533,244 (Bock et al.) 24 MARCH 1993, see page 4 and examples.	1, 2, 5-12, 15-17 ----- 3-4, 18-23, 26, 29 ----- 13, 14
X -- A	EP, A, 0,533, 243 (Gilbert et al.) 24 MARCH 1993, see page 4 and examples.	1, 2, 5-12, 15-17 ----- 3, 4, 13, 14, 18-23, 26, 29

Form PCT/ISA/210 (continuation of second sheet)(July 1992)★

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US94/13483

A. CLASSIFICATION OF SUBJECT MATTER:

IPC (6):

C07F 9/36; C07D 221/20, 227/12, 227/087, 401/12, 401/14; A61K 31/445, 31/675

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US94/13483

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.: 27-28, 24, 25
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

It cannot be determined what the scope of the embraced compounds is. No structural requirements of any type are given; the functional requirement is unsearchable.

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
☐ No protest accompanied the payment of additional search fees.